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REPORT OF THE NATIONAL CONSERVATION COMMISSION

WITH ACCOMPANYING PAPERS

FEBRUARY
1909

SPECIAL MESSAGE FROM THE PRESIDENT OF THE UNITED STATES

TRANSMITTING A REPORT OF THE NATIONAL CONSERVATION COMMISSION, WITH ACCOMPANYING PAPERS

IN THREE VOLUMES

VOLUME II

EDITED UNDER THE DIRECTION OF THE EXECUTIVE COMMITTEE BY HENRY GANNETT

WASHINGTON
GOVERNMENT PRINTING OFFICE
1909

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SENATE OF THE UNITED STATES,
February 18, 1909.

Resolved, That the special message from the President of the United States, transmitting a report of the National Conservation Commission, with accompanying papers and illustrations, be printed in full as a document, taking number 676 of the present Congress, the number of the document containing the special message of the President transmitting this report.

II

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ACCOMPANYING PAPERS

WATERS AND FORESTS

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PREFATORY NOTE.

The following papers were prepared by the experts under whose names they appear and who assisted the commission in its labors. These papers form the body of information on which the report of the commission is based and from which the statements of the secretaries have in the main been prepared.

Naturally, these papers, representing as they do the original work of experts along various lines pertaining to the resources of the country, express some diversity in views. Since each opinion is that of an expert, the commission has not deemed it wise to undertake either acceptance or elimination of the views; and has decided, without expressing its own opinion, to leave the experts' views to the test of time as our knowledge extends and becomes more definite.

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ESTIMATES OF FUTURE POPULATION.

By HENRY GANNETT,
United States Geological Survey.

Under normal conditions, the rate of increase of a body of population slowly decreases. Other things being equal, as the density of population increases and as the difficulty of breadwinning becomes greater with diminished opportunity, natural increase and immigration decrease. The rate of increase may, and frequently has been, affected by disturbing factors, causing it to increase temporarily or to decrease more rapidly than normal. As an illustration, the population, increase in numbers, and rates of increase in the United States by decades from 1790 to 1900 are given in the following table:

Year.	Population.	Increase.	Rate of increase.
			Per cent.
1790	3,929,000		
1800	5,308,000	1,379,000	35
1810	7,240,000	1,931,000	36
1820	9,638,000	2,399,000	33
1830	12,866,000	3,228,000	33
1840	17,069,000	4,203,000	33
1850	23,192,000	6,122,000	36
1860	31,443,000	8,251,000	36
1870	38,558,000	7,115,000	23
1880	50,156,000	11,597,000	30
1890	62,622,000	12,466,000	25
1900	75,569,000	12,946,000	21

From 1780 to 1840 the population was little disturbed and immigration was small, and the rate of increase dropped from 35 or 36 per cent to 33 per cent. Between 1840 and 1850 there was a great wave of immigration, which increased in the succeeding decade and raised the rate of increase to 36 per cent. Then came the blighting effects of the civil war; deaths from casualty and diseases and the reduction of births (aided to an uncertain extent by omissions in the census of 1870) reduced the rate in that decade to 23 per cent. Between 1870 and 1880 the country began to recover from the effects of war, and the rate of population increased to 30 per cent. The succeeding decade witnessed a drop of 5 per cent, and the following one of 4 per cent. Thus in 110 years the rate of increase of population has been reduced from 35 to 21 per cent. If normal conditions prevail in the future, it is certain that the rate of increase will continue to diminish until the rate reaches that of the densely populated countries of western Europe—about 10 per cent increase per decade. It will be noted that in the table the numerical increase has been steady excepting for the period between 1860 and 1870.

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A great variety of population conditions exists in the United States. There are communities where increase is supplied wholly by immigration; others receive no immigration, but are dependent upon the excess of births over deaths; there are regions where commerce and manufacturing cause dense population; thickly populated farming regions now passing into manufacturing communities; prosperous farming regions; sparsely peopled pastoral lands; and desert wastes with few people. All have different rates of increase, and the figures discussed represent the total of all these different conditions.

Several predictions of our population have been made at various times by different and by more or less complicated and elaborate methods. One or two of these predictions have by accident hit very near the truth, as made known by later censuses, but all have been finally wide of the mark.

A mathematical method which has been employed consists in deducing the equation of the curve which the population has made, beginning with the first census and ending with the latest available, and so projecting this curve into the future. Such a formula expresses past conditions with accuracy, but its application to the future assumes that similar conditions will prevail hereafter, which is extremely unlikely.

A simple method which has been employed is to assume that the numerical increase of each decade will continue the same and be equal to that of the latest decade measured by the census, at present that of 1890 to 1900, when the increase was 13,000,000. It is not probable, however, that the numerical increase will remain stationary, but will increase still more. Great Britain, with 347 inhabitants to a square mile, shows a continual increase in its decennial increment, and other densely populated European countries show the same. Hence, it is believed that such predictions are somewhat too small.

Another simple method assumes that the rate of increase, which was 21 per cent from 1890 to 1900, will decrease by a certain per cent each decade, say 1 per cent, being 20 per cent between 1900 and 1910, etc.

It is probable that for several decades the amount of reduction in the rate of increase will be greater than 1 per cent, and that then the rate of its reduction will be slowly lessened, so that perhaps a century hence, in the year 2000, the rate of increase may be 10 or 11 per cent, but the population will not be as great. As a guess, the population in 2000 may be placed at a figure not very far from 250,000,000, or about midway between the results given by these two methods.

Accepting the above figures, the following table shows by decades the probable population and rates of increase until the year 2000, with the guess extended a century further into the future:

Year.	Population.	Increase.	Year.	Population.	Increase.
		Per cent.			*Per cent.*
1900	76,000,000		2010	274,000,000	10
1910	90,000,000	21	2020	299,000,000	9
1920	104,000,000	16	2030	325,000,000	9
1930	119,000,000	14	2040	350,000,000	8
1940	134,000,000	13	2050	375,000,000	7
1950	150,000,000	12	2060	400,000,000	7
1960	167,000,000	10	2070	425,000,000	6
1970	184,000,000	10	2080	450,000,000	6
1980	202,000,000	10	2090	475,000,000	5
1990	225,000,000	11	2100	500,000,000	5
2000	249,000,000	11			

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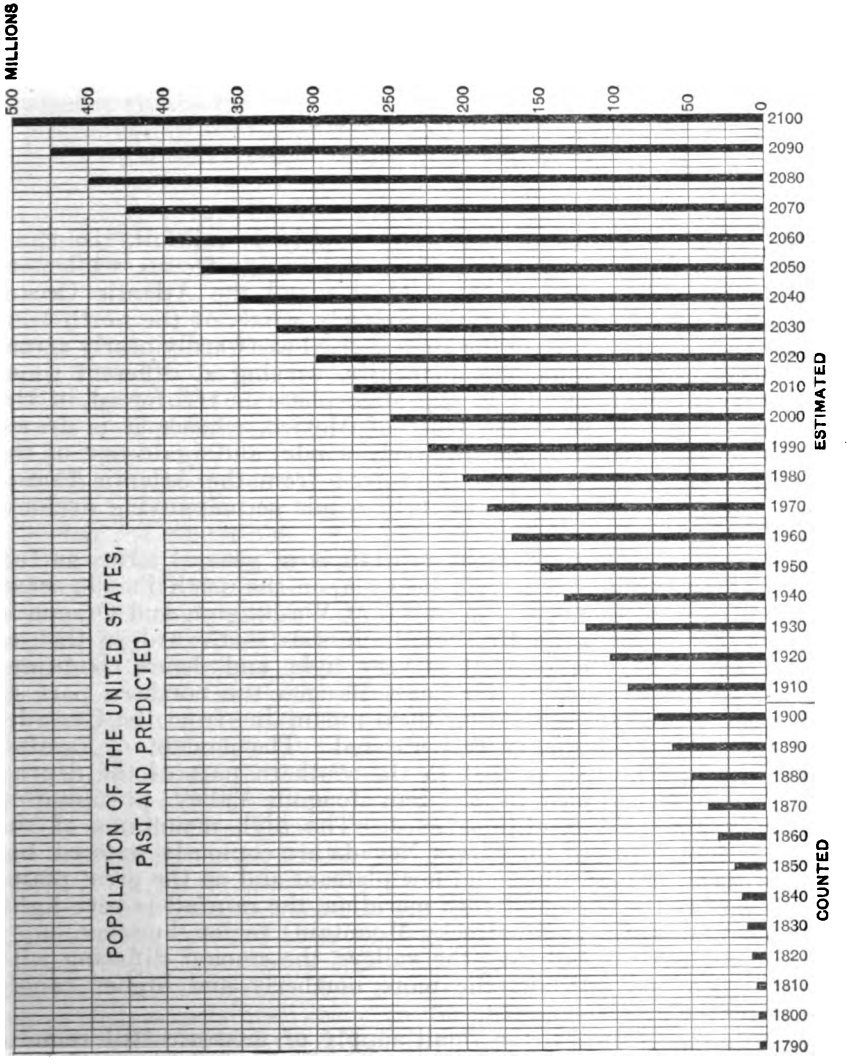
Thirteen countries of Europe, including all the larger, older, and most densely settled ones, which comprise collectively a population of 260,000,000, show a decennial increase of population in the last decade of 24,400,000. Here is a case approaching parallelism with what the United States may expect to be ninety or one hundred years hence.



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DISTRIBUTION OF RAINFALL.

By HENRY GANNETT,
United States Geological Survey.

The ultimate source of our water supply is rainfall, the chief source of which is evaporation from the Pacific Ocean, while secondary sources are the Gulf of Mexico and the Atlantic Ocean. Brought from the Pacific by the westerly winds of the north temperate zone, the moisture in the air is carried eastwardly nearly across the continent in diminishing quantities, varying at different times of the year. The supply in the atmosphere is reenforced in the Mississippi Valley from the Gulf of Mexico, whence it is drawn inland by southerly and southwesterly winds; and again east of the Appalachian Mountains it is reenforced from the Atlantic Ocean, from which it is drawn by easterly winds accompanying cyclonic disturbances.

The areal distribution of the rainfall is in general terms as follows: The precipitation is very heavy upon the north Pacific coast, where at several points in the States of Washington and Oregon it exceeds 100 inches annually, but diminishes southward so that at San Diego, Cal., the rainfall is very light and desert conditions prevail. Inland, back of the Coast Ranges, the northern part of the great depression separating these mountains from the Cascades and the Sierra Nevada is well watered. The amount of rainfall diminishes southward, so that in the southern part of the depression, which is occupied by the San Joaquin Valley, precipitation is scanty and arid conditions exist. The high mountains of the Cascade Range and of the Sierra Nevada are copiously watered, but east of them, in the valleys and low plateaus and on the great plains as far east as the one hundredth meridian, the rainfall is very light. The mountains of this (the Rocky Mountain) region, however, enjoy a more copious rainfall than the valleys, the amount differing with the altitude and latitude, the more northerly and higher ranges receiving the greater amount.

Continuing eastward, the small supply of moisture still remaining from that brought from the Pacific Ocean is augmented by a generous contribution from the Gulf of Mexico, and the rainfall increases. Upon much of the Gulf coast it exceeds 60 inches annually, but it diminishes northward, until in the neighborhood of the Great Lakes the precipitation does not exceed 30 inches yearly. The Appalachian Mountains are abundantly watered, and the Atlantic plain receives everywhere a sufficiency for agricultural purposes, derived largely from the Atlantic Ocean.

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The causes of these great differences in amounts of precipitation in the various parts of the country are simply explained. All air holds a certain amount of moisture, ranging from the amount sufficient to saturate it to a very small proportion of that quantity. The point of saturation is much higher in warm air than in cold air; i. e., warm air can hold a much larger quantity of moisture than can cold air. Whenever air is cooled below the point of saturation, rain falls, and it can only fall when thus chilled. There are several ways in which air currents may be cooled; the current may be forced upward, as when it climbs the slope of a mountain range; it may be cooled by intermingling with colder air currents; and again, by coming in contact with a cold land.

The sea receives heat slowly and parts with it slowly; the land, on the contrary, is rapidly heated and parts with its heat as quickly. It results from these conditions that the ocean has a fairly uniform temperature the year around, while the land is much colder in winter than in summer.

Now, let us apply these principles to the United States. The prevailing winds in the Temperate Zone are from the west. These winds come off the Pacific laden with moisture and having the temperature of the ocean. If they encounter land having a lower temperature they are chilled below the point of saturation and some of the moisture is deposited in the form of rain or snow. If, on the other hand, the land is warmer than the air, the currents pass over it without any reduction in temperature and with little or no loss of moisture.

During the winter the north Pacific coast is colder than the sea, and hence the copious precipitation which it enjoys at that season of the year. In the summer the conditions are reversed, and the air currents, although containing at least as much moisture as in cold weather, pass over the land with comparatively little loss from precipitation. Southward, down the coast, the land is progressively warmer in winter, and consequently receives less rain, while in southern California there is little rain even in winter, except upon the mountains. Although the atmosphere at Los Angeles contains more moisture than does that at Washington, D. C., rain seldom falls in the former locality, as there is nothing to cool the air currents.

Thus it is that the Pacific coast has well-defined wet and dry seasons corresponding to winter and summer in other parts of the country. In winter the country drains the air currents of their moisture and they pass eastward as dry winds, while in summer these currents carry most of their moisture over the mountains and precipitate it upon the Rocky Mountains farther to the east and upon the great plains. Hence, it is that in these two regions the greater part of the year's rainfall occurs in the warmer half of the year.

Going eastward into the Mississippi Valley the moist air currents, drawn northward from the Gulf of Mexico by southerly winds, are carried progressively into more northerly and colder climates, and part of their moisture is deposited in a similar manner.

The Weather Bureau has furnished the Commission with data upon precipitation from about 4,000 stations within the limits of the United States proper. These data consist of records of the normal yearly and monthly rainfall, and the study which has been made of them is very illuminating.

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For the preparation of a rainfall map, the data from all these stations were platted upon a large-scale map of the United States, and in the plains and level country generally isohyetal lines were sketched at intervals of 10 inches of rainfall in accordance with these data. In the mountain regions, however, but little weight was given to the rainfall data, inasmuch as the stations are generally situated in the canyons rather than on the ridges, and hence do not represent well the rainfall of the region, but in such country consideration was given to the relief of the land, its mountains, etc., and to the character of its vegetation; it is known, for instance, that the lower limit of yellow pine timber is not far from the isohyetal line of 20 inches. The areas between these isohyetal lines were measured by planimeter, and the average rainfall of each such area was assumed to be the mean of the two isohyetal lines limiting it. The areas were then multiplied by their average rainfall, the products summed up, and the total divided by the total area of the country. In this way the figure, 29.4 inches, was obtained as the mean average rainfall of the United States.

Another use has been made of these data. The percentage of the annual rainfall which was received during the six warmer months was computed for each station, and the results platted upon a map, which thus shows the preponderance of summer or winter rainfall throughout the country. Over most of the area the greater part of the rain occurs in the warmer season, but upon the Pacific coast and in the Rocky Mountains as far east as western Montana, eastern Idaho, eastern Utah, and Arizona the bulk of the precipitation comes in the colder season. The highest proportion, three-fourths to four-fifths of that of the year, is on or near the Pacific coast, and the proportion diminishes eastward. Again, in an area adjacent to the Gulf of Mexico, winter rainfall preponderates slightly. The highest proportional summer rainfall is on the plains east of the Rocky Mountains, where it ranges from three-fourths to four-fifths of that of the year. In the Mississippi Valley and on the Atlantic plain the proportion which falls in the warmer season is but little more than half of the annual precipitation.

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TRANSPORTATION BY WATER.

By HERBERT KNOX SMITH,
Commissioner of Corporations.

Part I.—GENERAL CONDITIONS OF TRANSPORTATION BY WATER.

The first part of this discussion on Transportation by Water in the United States deals with the general conditions of such transportation, involving the following topics:

(1) The natural and artificial coastwise and inland waterways, and the character and results of the more important improvements thereof.

(2) Vessel equipment, types, and number and tonnage.

(3) Vessel ownership, business organization, and finances of navigation lines and companies, in regular lines, bulk carriers, and towing concerns.

(4) Contracts for the carriage of goods, shipping documents, the liability of carriers, and statutes relating thereto.

(5) Marine insurance and its general influence on water transportation.

(6) Taxation of vessels and of navigation companies.

The present Part I is of a somewhat preliminary nature. It sets forth mainly conditions familiar to those in the business, though not hitherto presented to the public in complete form. Such a survey of conditions is necessary as a preparation for the discussion of the specific branches of the subject in subsequent parts of this report.

This report deals only with domestic traffic, except so far as foreign traffic is incidentally involved in such discussion. The domestic water-borne traffic carried by vessels of the United States is far larger than the foreign trade so carried, and of much greater importance. Coastwise traffic is by law restricted to American vessels. Most of the foreign trade is carried in foreign vessels. Domestic coastwise commerce, however, uses the same ports as does the foreign commerce, and the early policy of the Government in improving these ports, with especial view to foreign trade, gave also especial advantage to coastwise trade. In physical characteristics also the coastwise business is of the same class as foreign business, while the two differ largely from inland water traffic.

WATERWAYS AND THEIR IMPROVEMENT.

Interstate commerce moves on natural and artificial waterways. The former embrace the Atlantic and Pacific coasts and the Gulf of Mexico, the Great Lakes, and numerous navigable streams. These natural waterways have been greatly improved. Artificial waterways are government, state, and private canals.

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COAST LINE.

The Atlantic coast line of the United States is more than 2,000 miles in length, and it is extended for another 1,900 miles by the Gulf of Mexico. The Pacific coast line is more than 1,800 miles long. The total coast line of the United States aggregates 5,700 miles. This is increased to a meandered length of 64,604 miles by including the numerous indentations, many of which provide important bay, sound, and inlet routes. Chief of these are the Gulf of Maine (so-called), Long Island Sound, Delaware Bay, and Chesapeake Bay, on the Atlantic coast, and Puget Sound, on the Pacific coast.

GREAT LAKES.

Next in significance are the Great Lakes, the most important group of inland waterways in the world. Their shore line in the United States territory is 2,760 geographical miles. The meandered length is 4,329 miles. They are connected by a series of natural and artificial channels. Canals also connect the Lakes with the Atlantic Ocean and the Mississippi and Ohio rivers, but these are not of dimensions to permit of through navigation by large vessels. Another series of canals, constructed by the Canadian government along the St. Lawrence River, give 14 feet draft to Montreal, and are used to some extent by American vessels.

On the coasts the Government has deepened harbors and connecting channels. Similar works on the Great Lakes give a depth of 20 feet on the main channels.

COAST AND LAKE ROUTES.

The coastwise trade routes radiate mainly from a few central ports, such as Boston, New York, Philadelphia, and Baltimore, on the Atlantic coast, and San Francisco, Portland, and Seattle, on the Pacific. On the Lakes, notwithstanding the large number of routes, the great movement of traffic follows a few well-defined main lines. Most important is the route from Lake Superior ports through Lake Huron to Lake Erie ports. Another main route, formerly the most important, is that from Lake Michigan ports to ports on Lake Erie.

RIVERS.

The number of navigable streams used to a considerable extent for commercial purposes in the United States is about 295, with an approximate mileage of 26,400.

Number and mileage of navigable streams in the United States, by districts.[a]

	Streams.	Navigable length.		Streams.	Navigable length.
		Miles.			*Miles.*
Tributary to the Atlantic	148	5,365	Flowing into Canada	2	315
Tributary to the Gulf, exclusive of the Mississippi and tributaries	53	5,212	Tributary to the Pacific	38	1,606
Mississippi River and tributaries	54	13,912	Total	287	26,410

[a] No classification of this sort can, of course, be absolutely accurate. Sections of a river that might be rendered navigable are not included, nor streams practically abandoned for navigation purposes. There are also many small streams navigable for very light vessels in local commerce which have not been included.

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The chief of these are:

Navigable lengths and depths of principal rivers of the United States.

Rivers.	Navigable length.	Depth.	Rivers.	Navigable length.	Depth.
Atlantic coast:	*Miles.*	*Feet.*	Gulf of Mexico—Continued.	*Miles.*	*Feet.*
Penobscot	27.0	11.0	Atchafalaya	156.0	.....
Kennebec	44.0	10.0	Calcasieu	58.0	3.5-12.0
Connecticut	50.0	10.0	Sabine	64.0	5.0
Hudson	150.0	[a] 9.0	Neches	135.0	3.0
Delaware	82.0	[b] 6.0	Brazos	260.0	- 4.0
Potomac	113.0	18.0	San Jacinto (Buffalo Bayou)	27.0	7.5-18.5
Rappahannock	106.0	7.5	Mississippi system:		
York	41.0	20.0	Mississippi	2,429.0	2.0-32.0
James	103.8	16.0	Below New Orleans	.....	32.0
Pamlico and Tar	108.0	2.5- 8.5	New Orleans to St. Louis	.....	9.0
Cape Fear	145.0	(c)	St. Louis to St. Paul	.....	4.5
Waccamaw	147.0	2.0-12.0	Above Minneapolis	.....	3.0
Pedee	172.0	2.0- 8.0	Ohio	967.0	4.2-21.0
Santee	143.0	4.0	Monongahela	131.0	7.0
Savannah	250.0	[d] 3.0-21.0	Kanawha	90.0	6.0
St. Johns	276.0	[e] 2.0-20.0	Green and Barren	227.0	5.0
Gulf of Mexico:			Cumberland	518.0	.....
Withlacoochee	77.0	2.0- 5.8	Tennessee	652.0	1.5- 3.0
Suwanee	135.0	4.0- 5.0	Missouri	2,414.0	.....
Apalachicola, Flint, and Chattahoochee	465.0	3.0- 6.0	Yazoo	173.0	3.5
Alabama	312.0	3.5	Ouachita and Black	436.0	.....
Coosa	198.0	2.0-	Red	500.0	2.0
Mobile	45.0	14.0	Pacific coast:		
Tombigbee	341.0	3.0- 6.0	San Joaquin	200.0	3.0-8.0
Warrior and Black Warrior	154.5	6.0	Sacramento	262.0	2.5- 7.0
Pascagoula	55.0	5.0-15.0	Columbia	336.0	[f] 3.5-20.0
Bayou Plaquemine, etc	11.0	.....	Willamette	164.0	[f] 3.0-22.0
Bayou Teche	75.0	4.0	Snake	146.0	3.5
Bayou Lafourche	105.0	3.0			

[a] 25 feet to Hudson.
[b] 23 feet to Philadelphia.
[c] 20 feet to Wilmington, 8 feet to Kings Bluff, and 2 feet to Fayetteville.
[d] 21 feet to Savannah.
[e] 20 feet to Jacksonville, 5 feet to Sanford.
[f] 20 feet to Vancouver, Wash., and Portland, Oreg., 8 feet to The Dalles.

LACK OF UNITY IN WATER SYSTEM.

The streams tributary to the Atlantic do not form connected systems, but often form extensions of coastwise routes into the interior. Streams tributary to the Gulf are more often connected with each other, foremost being those of the Mississippi Valley system, which aggregate about 14,000 miles. On the Pacific coast there are also several connected systems, such as the rivers leading into Puget Sound, the Columbia River and its tributaries, and the rivers of central California.

Most streams included in the foregoing table are navigable only for light-draft boats. Forty streams have a total of about 2,600 miles of 10-foot navigation, and 70 streams give about 3,200 additional miles of navigation of from 6 to 10 feet during the greater part of the year, a total of about 5,800 miles of river navigation of 6 feet and over. These totals, however, do not of course mean that there are any such continuous stretches of inland waterways of these respective depths. The greater number of these streams flow into the Atlantic, but few of the Atlantic rivers have more than 100 miles of navigation over 6 feet in depth. The longest connected river system is the Mississippi and its principal tributaries, with about 2,500 miles of a depth of 6 feet or more.

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It is evident that rivers having a navigable depth of only 6 feet can not be used by vessels suited to ocean or Great Lake navigation, and furthermore, that vessels which give the most economical service on rivers having that depth can not be used on still shallower rivers. These facts, together with the shortness of the navigable length of most rivers having a 6-foot depth and their unconnected character, are of great importance in estimating the present value of our inland waterways. It is evident that these waterways constitute by no means a unified system. The predominating importance of through traffic in modern transportation makes this lack of unity a serious defect, and accounts to a considerable degree for the failure of our waterways to hold their own in competition with the rail system.

CANALS.

About 4,500 miles of canals have been constructed in the United States. Of these, 2,444 miles, costing in all about $80,000,000, have been abandoned.

The height of interest in canal building came about 1827 to 1837, after the success of the Erie Canal. The crisis of 1837 stopped canal building for the time. The introduction of the railroad about this time was also an important factor in this decline. Since then the use of canals has been as a whole steadily decreasing, both in absolute amount and still more markedly in proportion to the total traffic of the country.

This is due in part to improvident original location of the canals, in part to mismanagement and to adverse control of strategic connections and terminals, but above all else to the fundamental inability of the ordinary type of towpath canal to meet modern conditions of transportation. They are thus unable to compete with railroads to any considerable extent.

Notwithstanding these facts, private and State canals still exist. State canals are maintained in New York, Ohio, Illinois, and Louisiana, with a total mileage of nearly 1,360, constructed at a cost estimated at $156,983,538, as follows:

State canals in operation in the United States.

Name and location.	Termini.	Length.	Depth.
New York:		*Miles.*	*Feet.*
Erie	Buffalo and Albany	355.1	7
Champlain	Troy and Whitehall	81.0	5
Oswego	Oswego and Syracuse	38.0	7
Cayuga and Seneca		25.0	7
Ohio:			
Ohio and Erie	Cleveland and Portsmouth	326.0	4
Miami and Erie	Toledo and Cincinnati	269.0	4–6
Illinois and Michigan	Chicago and La Salle	101.9	6
Chicago Sanitary and Ship Canal	Chicago and Lockport	33.0	22
New Basin Canal (Louisiana)	New Orleans	6.7	8

The Ohio and Illinois canals are antiquated waterways, with little traffic; and the Erie Canal, in spite of its important past, is inadequate in its present condition to meet modern traffic demands, although the new barge canal in course of construction by the State of New York is intended to give a revival of this route.

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There are 16 private canals in operation in the United States of more than local importance, with an aggregate mileage of 632, as follows:

Private canals in operation in the United States.

Name of canal.	Termini.	Length.	Depth.
		Miles.	*Feet.*
Delaware and Raritan	New Brunswick and Bordentown	66.0	8–9
Morris	Phillipsburg and Jersey City	106.7	5
Lehigh	Coalport and Easton	48.0	6
Delaware Division	Easton and Bristol	60.0	6
Schuylkill Navigation		90.0	6½
Chesapeake and Delaware		13.6	10
Chesapeake and Ohio	Cumberland and Georgetown	185.0	6–7
Dismal Swamp		22.1	9
Albemarle and Chesapeake		11.0	9
Fairfield (North Carolina)		4.0	6
Newbern and Beaufort (North Carolina)		3.2	5
Old Basin (Louisiana)		2.5	7
Barataria and Lafourche (Louisiana)		7.0	6
Harvey's (Louisiana)		5.35	6
Lake Borgne (Louisiana)		7.0	7
Willamette Falls (Oregon)		.6	6

The capital stock reported by 8 companies owning these canals is $43,326,539. Their total indebtedness as reported to the Bureau is $38,307,740. The more important private canals are those comprising the Atlantic coast system, which connect natural waterways so as to furnish continuous inland communication for light-draft vessels from the sounds of North Carolina to Long Island Sound, though their use for such long-distance traffic is wholly insignificant. Most of these canals have a declining traffic. Little has been done in the way of improving them since the civil war; and several have come into the possession or control of railroads, which appear to discourage their use. The control of canals by private interests does not appear to be successful. Such private control also to some extent impedes free use of the natural waterways with which they are connected.

The "towpath canal," forming a route in itself, and not a mere short connecting link or extension of deep open routes, is wholly outclassed in attempting to meet the demands of modern transportation. Using animal power, they are too slow for most high-grade traffic. The depth of water seldom exceeds 7 feet, so only small boats can be used. Moreover, it is unable to furnish feeder lines, factory sidings, etc., with the ease of the rail system. The bulk of our traffic is now so largely long-distance that even the longest canal can not depend on traffic wholly originating and terminating within its limits; and when it thus has also to seek long-distance traffic, for which it is merely one link in the chain, it meets heavy rail competition, difficulties of transshipment, and difficulties of connecting terminals. This struggle is so keen that the slightest original disadvantage may easily determine the issue.

The question as to the value of a canal for steam-towed barges of 1,000 to 1,500 tons is still to be determined by practical use.

WATERWAY POSSIBILITIES AND LIMITATIONS.

At first glance the possibilities of our present natural system, if properly developed, seem great; but any proper plan of development

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must first consider in detail a number of physical and economic restrictions, which place very decided limits on waterway traffic, especially inland river traffic. Differences in types of waterways are of great importance. The extreme physical differences between deep, open water routes, like the sea or the lakes, and the shallower, winding, and narrow channels of rivers and canals, make the use of the two not at all comparable. Arguments as to one can not be safely based on the facts of the other. A corresponding difference in types of vessels suitable thereto and now used thereon is a natural consequence. These two conditions impose great restrictions on the complete unification of the system, and what may be called the interchangeability of the floating equipment, and consequently on through shipments.

This lack of unity and of interchangeability is a factor of enormous importance in the use and development of waterways and their relations with the railroad system.

GOVERNMENT AND STATE IMPROVEMENTS.

Until about 1850 the improvement of navigable streams and the construction of artificial waterways in the United States were principally carried on by the several States and by private corporations. Both classes of enterprises, however, were sometimes encouraged by the United States Government, either by appropriations or, more frequently by land grants and subscriptions to stock.

Since about 1870, the date of the present form of the river and harbor bill, the policy of the United States Government has undergone a radical change. Many improvements formerly conducted by States and private corporations have been taken over by the Government, and the amounts appropriated for waterway improvements have been largely increased. The total federal appropriations for river improvements and canals (excluding harbor works) to 1907 have been about $250,000,000.

Canals owned by the Government form links in through-water routes, such as the St. Marys Falls Ship Canal, rather than distinct routes in themselves. The improvement of rivers by the Government has consisted in the removal of obstructions to navigation, the deepening of channels, the construction of revetments, and the development of slack-water navigation by the building of locks and dams for the purpose of maintaining a proper depth. Such improvements have been carried out to some extent on most of the navigable streams of the country, the most comprehensive and connected system of river improvement being that of the Mississippi and some of its important tributaries.

COOPERATION IN IMPROVEMENTS.

In the development of our waterway system, while undertaken in part by state and later and more extensively by federal power, there has been very little of that cooperation between central and local authority that appears in the best of the European systems. The United States, the States, the counties, levee districts, and municipalities have all spent large sums of money on waterway improvement, but for the most part separately. There has thus been waste,

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lack of uniformity, lack of comprehensive plan, and especially a lack of any proportionate contribution from localities peculiarly benefited.

While it is true that the entire country is to some extent interested in a good waterway system in each part thereof, nevertheless it must be remembered, as pointed out above, that any complete unification of that system is, for the present at least, physically impossible, and that therefore the traffic on such waterways will remain for a time confined to certain large sections of the country, and the benefits thereof will also to a considerable degree be local. European countries have in many cases met a similar condition by a distribution of costs of improvements apportioned upon localities in some ratio to special benefits received.

EQUIPMENT EMPLOYED IN TRANSPORTATION BY WATER.

TYPES OF VESSELS.

These include various classes of craft, such as sailing vessels, steam vessels, gasoline boats, barges, and canal boats. Steam vessels show a continuous and rapid increase both in number and tonnage. They have exceeded sailing vessels since 1895 and now have more than double the tonnage. Sailing vessels have declined in importance since 1860. There has also been a notable increase in the number of barges hauled by towboats, especially on the Mississippi and its tributaries and on the Atlantic and Gulf coasts, showing an important change in the form of traffic movement. The total number of unrigged craft in the United States in 1889 was 16,937, as compared with 20,263 in 1906.

Special recent developments in the types of vessels are particularly noticeable in regard to vessels for bulk cargoes. Thus there are the grain and ore bulk carriers on the Great Lakes; steam freighters and coal, fruit, and oil carriers on the Atlantic and Gulf coasts; and steam schooners on the Pacific coast. The competition of such vessels with sailing vessels has, in turn, led to the building of four, five, six, and seven masted schooners. Older sailing vessels are often converted into schooner barges, which are towed from port to port. Gasoline boats are coming into use for local traffic on the rivers of the Mississippi Valley and on the Pacific coast. A type sui generis is the log or lumber raft, notably the huge "cigar rafts" on the Pacific coast.

VESSEL TONNAGE.

The total gross tonnage of documented vessels engaged in the domestic trade in 1896 was 3,858,927 tons, and in 1906, 5,735,483 tons, a gain of 1,876,556 tons, or 48 per cent. The tonnage of American vessels engaged in the foreign trade, after reaching its maximum in 1860, has continued to decline except for a slight increase since 1900. In 1896 it was 884,954 tons, and in 1906, 939,486 tons, an increase of only 94,532 tons, or 11 per cent.

The distribution of domestic vessels by districts in 1907 shows that the Atlantic and Gulf coasts are the most important districts, including nearly half of the total documented tonnage and two-thirds of the sailing-vessel tonnage. The Great Lakes have more than one-third of the total documented tonnage and almost half the total documented steam tonnage of the United States.

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There has been a notable increase in the size of vessels on the coasts and the Great Lakes, similar to the increase in the size of railroad rolling stock, and with similar results in the reduction of transportation costs. As a general rule, and with vessels of the same type, the larger the vessel the lower the cost of carriage.

The size of vessels is, however, limited in nearly all cases by the depth of channels and harbors and by the terminal accommodations. Though the limits vary widely on different classes of waters and at different ports and channels, it may be said in general that a great many vessels have already been built with as great draft as the waterways they use will permit, and that in the case of most of our rivers and canals the maximum draft of vessels is scarcely sufficient to permit very economical operation. This fact has an important bearing on the possibilities of successful water transportation.

DIVERSITY IN VESSELS.

Reference has already been made to differences in depth of different classes of waterways as requiring differences in the size of vessels. These necessitate transshipment in order to secure through transportation, even between points both of which are on connecting waterways. Other differences in physical conditions of different kinds of waterways also prevent the use of the same vessels for through shipments. Thus vessels used on quiet inland waterways, such as smaller inlets and lakes and on rivers and canals, are neither sufficiently strong nor have they sufficient freeboard to permit them to be used on the Great Lakes or the ocean. Naval architects even assert that were there enough channel depth to take vessels from the Great Lakes to tidewater, nevertheless it would be preferable, and almost necessary, to transship at tidewater as now. Ore vessels on the Great Lakes, they state, are not in model or in structural strength adapted for ocean conditions.

Again, the narrowness and tortuousness of river channels almost entirely prevent the use of sailing vessels, and practically also prevent the use of large steam vessels such as are adapted to the Great Lakes or the ocean. Thus, even on a channel as deep as the Hudson practically no large ocean boats are seen at any considerable distance above New York, though there is 25 feet depth of water up to Hudson, 100 miles above New York. Owners do not care to risk the dangers of a restricted channel with large ocean-going craft. Again, in the present state of the art, even light-draft screw steamers can not be used to advantage, generally, on the Mississippi at any considerable distance above New Orleans. Aside from the shallow depth, the need for constant backing and turning at the innumerable bends makes the stern-wheel paddle the only generally successful method. The latter, of course, is useless on the open sea.

SPECIALIZATION OF BULK-CARGO VESSELS.

Specialization in vessels is not only with respect to the peculiar condition of the waterways, but it has gone further in adapting them to the peculiar conditions of the different kinds of traffic. This adaptation is especially conspicuous in what are known as bulk-cargo vessels; that is, vessels which do not carry package freight, or diversified

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freight, but which carry one or at most a few kinds of articles in bulk. Thus on the Great Lakes bulk steam vessels for ore or coal, and others for grain, are used to an enormous extent. On the Atlantic and Gulf coasts there are bulk vessels for coal, for oil, for fruit, etc. On the Pacific coast a type of steam schooner has been developed, especially intended for hauling lumber in bulk, and special lumber vessels are also used on the Great Lakes and the Atlantic Ocean. On the Ohio and Mississippi bulk coal barges are extensively used, and other bulk boats to some extent. The use of rafts of logs on the Great Lakes, on the rivers, and on the Pacific coast is a special development of bulk transportation.

The great predominance of bulk traffic emphasizes this specialization in vessels. On the Great Lakes steam bulk freighters carry about 80 per cent of the total business. The bulk coal traffic on the Atlantic and lumber traffic in steam schooners on the Pacific represent an important part of the total coastwise commerce. On the rivers of the Mississippi Valley the bulk carriers and rafts handle about three-fourths of the total traffic.

This development of the bulk water carrier is highly significant of the peculiar demands of modern transportation. It has been most successful in those cases where the products to be shipped are either on or very near the water, and where the destinations to be reached are likewise on or near the water. This is conspicuous, for example, in the case of the coal carried on the Monongahela, Ohio, and Mississippi rivers, most of which is produced at or very near the rivers. At the same time a large part of the traffic in bulk water carriers reaches those carriers only by rail haul, and a considerable part is delivered by rail to the final destination. This occurs, as on the Lakes, where there is a large uniform supply, a corresponding demand, and a proportionately long water haul connecting the two.

This specialization of types of vessels, as in the various classes of bulk freighters, in the use of gasoline launches on the Mississippi River, etc., indicates the struggle of a system to adapt itself to its conditions. Probably had there been no rail competition, that adaptation would have gone much farther and would have approached something like a good operating system, even on the inferior waterways, such as rivers and canals. But in the keen struggle with the railroad for existence, hand-to-mouth methods have been necessary, except on the Great Lakes and the coast, and even there it is to some extent hampered by rail competition. Could the rail and water systems have cooperated instead of competing, it seems probable that a reasonable share of traffic would have produced a modern system of waterways transportation even on our smaller rivers.

From these considerations as to the character of our waterways, and of the vessels used upon them, it is obvious, as already stated, that our inland waterways are far from constituting a unified system, and that, save on the Great Lakes and in the coal traffic on the Ohio, they are very inferior in efficiency to railroads. In a later part it will be shown that the traffic on rivers and canals of the United States is insignificant in comparison with the rail traffic, or with traffic on the Great Lakes and the coasts. Diversity in water-route and channel conditions, diversity in vessel types, in motive power,

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and in terminals, as well as in carriers' liability, insurance, freight classification, and traffic contracts generally, have resulted in extreme absence of organization of our water system as a whole. It is thus helpless in competing for long-distance traffic with a modern, unified, standardized system like that of the railroads.

LIMITATIONS OF TRANSSHIPMENT.

It can not be expected that any reasonable expenditure on our inland waterways will wholly remove these difficulties. It would never pay, except in a few cases, to try so to deepen and improve the rivers and canals as to permit vessels suited to the ocean to use them to any appreciable extent. Transshipment from one water carrier to another will continue to be necessary on most long inland, or partly inland, hauls, even from and to points actually on waterways. Moreover, the greater part of our traffic originates in, or is destined to, points not on waterways, so that transsshipment from rail to water will always be necessary on most longer hauls which seek to use the waterways at all.

Since such a large portion of our traffic is long-distance traffic which will thus involve transshipment, the question of the future development of our inland waterways resolves itself into one of relative operating expenses and of investments of capital. There is little doubt that for a given distance a continuous water haul in a boat of even moderate size is, and will continue to be, cheaper in operating costs alone than a similar continuous rail haul. If the channels are made deep enough to permit the use of relatively large boats, this greater cheapness will, in some cases, probably be sufficient to cover also the additional cost of transshipment. The question is, however, whether besides doing so it will afford enough saving to cover reasonable interest on the investment in waterways and water terminals necessary to secure such measure of efficiency. This is a question which can only be answered after most exhaustive engineering estimates of the cost of constructing waterways of different depths and most thorough investigations of operating expenses of different kinds and sizes of vessels, in comparison with expenses of rail transportation.

It should be noted, however, in considering how far expenditures of capital for improved water routes are advisable, that in some cases the railroads have already reached the limit of their carrying capacity and that they will have to make additional investments of capital if they are to meet the demands of transportation. The relative amount of investment necessary thus to increase the facilities of the railroads, as compared with the investment necessary to afford adequate water routes and terminals, must therefore likewise be taken into account.

BUSINESS ORGANIZATION AND FINANCES.

OWNERSHIP.

Prior to the development of steam navigation vessels were usually owned and operated by individuals or small groups of individuals. Sailing vessels are even now more commonly thus owned than by corporations. The corporate form, however, has gained steadily, at first with steam vessels and later with sailing vessels and barge lines. There was a total of 37,321 vessels, with a total gross tonnage

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of 12,893,429 tons, and valued at more than $507,000,000, included in the census of 1906. Of these, corporations owned more than one-half of the number, and more than three-fourths of the total tonnage and value. Of steam vessels corporations controlled 42.6 per cent, representing 87.6 per cent of the gross steam tonnage; and of freight and passenger vessels running on regular lines they controlled 56.8 per cent, with 91 per cent of that tonnage. The proportion of vessel tonnage owned by corporations is everywhere larger than the proportion of the number of vessels so owned, indicating that the vessels owned by corporations are usually the larger ones. In 1906 the average size of vessels owned by individuals was 113 tons, of vessels owned by firms 223 tons, and of vessels owned by corporations 526 tons.

Many steamship corporations, however, are essentially private affairs, with few stockholders. They often are controlled by a few individuals, often of the same family. Navigation companies have been in most cases conservatively capitalized and their stock not offered in the open market. But in recent years there have been some notable changes in these respects. By expansion or consolidation there have been developed quite a number of great corporations with large fleets and operating many lines over a wide territory. The most striking instance of consolidation is that of the Consolidated Steamship Lines, commonly known as the Morse combination, including half a dozen important Atlantic coast lines, covering a large share of the regular packet-line business in this important district.

An especial feature has been the recent acquisition and operation of steamer and barge lines by railroad companies and by industrial and trading concerns, including several of the great combinations, such as the United States Steel Corporation, the Standard Oil Company, the Southern Pacific Railroad Company, the New York, New Haven and Hartford Railroad Company, the New York Central Railroad, the Pennsylvania Railroad, and others.

FINANCIAL.

The information available is inadequate for a satisfactory discussion of financial operations. The scope of the data is limited to a few of the most important facts relating to the capital stock (in case of corporations), indebtedness, gross earnings, and operating expenses. But even on these points the failure of many concerns to make any report renders the details incomplete, and only a few general and tentative conclusions can be drawn therefrom.

The information in regard to capital stock and indebtedness is more complete than in regard to earnings and expenses, but even there special difficulties are encountered. Where navigation lines are owned by railroads or industrial corporations there is usually no specific record of the capital invested in the navigation lines as distinguished from the remaining property of the corporation.

The aggregate capital stock of navigation companies reported to the bureau is $248,720,178; the aggregate bonds and other indebtedness is $170,387,005, making a total capitalization of $419,107,183. This is for 366 companies, operating less than half the total vessel tonnage in the United States.

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In the information as to earnings and expenses, the utter absence of anything approaching uniformity in the method of accounting makes the returns of limited value. The aggregate gross earnings of concerns reporting earnings and expenses amounted to $81,708,289, and their aggregate operating expenses amounted to $65,816,251, leaving net earnings of $15,892,038. Operating expenses thus averaged 80.6 per cent of the gross earnings, a ratio of operating expenses to gross earnings much higher for navigation lines than for railroads, which in 1906 showed a ratio, for the United States as a whole, of 66⅔ per cent. This is not surprising, as out of their own earnings railroads must pay large sums on account of the fixed charges for their roadbed, for which there are no corresponding charges in the case of most navigation companies.

An analysis of the ratio of operating expenses to gross earnings, by districts, is of interest.

	Lumber carriers.	Coal carriers.	Bulk carriers.	Packet lines.	River lines.	All lines.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Great Lakes	.....	.....	69.7	85.7	.....	77.2
Atlantic and Gulf coasts	.....	.....	83.3	79.2	.....	79.8
Mississippi and tributaries	.....	79.3	.....	.....	86.8	83.7
Pacific coast	75.8	.....	.....	[a] 85.7	84.7	85.4

[a] Ocean packet lines.

The bulk carriers on the Lakes show the smallest ratio of expense. This is natural, as a result of the great predominance of bulk-cargo traffic there and the high degree of specialization thus made possible in carrying and terminal methods. The highest ratio of expenses is for the packet lines on the Mississippi and southern rivers.

The high operating cost of the Pacific coastwise packet lines is somewhat misleading, due partly to the heavy loss of one company in a special branch of business since abandoned. The normal ratio there would be about 81 per cent.

The incomplete nature of the statistics and the absence of information as to the relation between the capitalization of navigation lines and the cost and value of their equipment and property makes impossible a comparison of the net earnings with the actual investment, to show correctly the profitableness of the business. It may be said, however, that in the case of the companies reporting, the average net earnings are a fair rate on the capitalization; but there are wide variations between different companies, some showing a very high rate of return on the capital, others reporting operating expenses in excess of gross earnings.

SHIPPING CONTRACTS AND DOCUMENTS.

Transportation by water is the oldest method of long-distance traffic. It is in large measure governed by a body of world-wide maritime usages of remote origin. These customs have, however, been modified by statute, especially since the development of inland navigation and its closer connection with railroads. Various ports also have local rules.

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In securing cargoes, regular steamship lines, like railroads, make use of traffic agents of their own, but in the case of bulk cargoes and "tramp" vessels ship brokers, acting for both parties, are often employed.

CHARTERS AND BILLS OF LADING.

The vessel may be let or hired by a charter, or the vessel may have a regular route, its owner or operator accepting shipments as a common carrier, in which case it is technically known as a "general ship." The two instruments most commonly employed in contracts of carriage are the charter party and the bill of lading. The former is a contract for the whole or a large part of the vessel; the latter for a smaller and varying portion of the vessel's capacity. There are numerous forms of both classes of documents employed, although efforts have been made to secure the use of uniform contracts.

The practice of leasing vessels is quite common throughout the United States. In some instances all the vessels of an operating company are chartered by it from the owners. Some vessels operated in the foreign trade are chartered by the year from foreign owners.

Bills of lading issued by vessels correspond in a general way to those issued by railroads. There is considerable diversity, especially in clauses limiting the liability of the carrier. The New York Produce Exchange steamship bill of lading is one often employed. Some clauses in many bills of lading appear to conflict with the provision in the Harter Act prohibiting a vessel owner from inserting stipulations to relieve himself from the results of negligence.

MANIFESTS.

These correspond to railroad waybills, showing the cargo of vessels on each voyage. In the case of foreign voyages, and on the Great Lakes, manifests must be filed with the customs officers; but they are not ordinarily required to be filed for other coastwise or river routes. This is a serious obstacle to the collection of complete statistics of water-borne traffic in the United States.

GOVERNMENT REGULATION.

The interstate-commerce acts have been applied only in a limited degree to carriers by water; and it is uncertain how far the provisions of these acts as to rates and carriers' liability are intended to apply to water lines. This is in marked contrast with the close supervision over vessels and their officers for the protection of life. In this latter respect water traffic has long been far more closely regulated by government control than railroad traffic. The detailed strictness with which the construction, operation, and maintenance of vessels is watched by the Government, and its complete system of inspection thereof, is in very marked contrast to the almost complete absence of such control over railroads. This difference, also, has borne with some disproportionate weight on the water traffic.

On the other hand, governmental control of rates has been much more complete over railways than over waterways.

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MARINE INSURANCE.

Marine insurance charges are an important factor as an addition to the cost of transportation by water, and they must be taken into consideration in comparing the relative economy of rail and water routes.

VARIATIONS IN POLICIES AND RATES.

Since the floating equipment and cargoes protected by insurance are of various kinds, there is a similar diversity in the types and stipulations of insurance policies. As regards vessels, there are river hull policies, ferryboat hull policies, inland hull, tug, yacht, schooner, and steamboat policies. As regards cargoes, there are cotton policies, coal, lake-cargo, and river-cargo policies. There are also blanket policies on hull and cargo and on all the vessels and cargo of particular lines.

There is considerable variety both in the manner of effecting insurance on vessels and cargoes and in rates of premium, not only on the different waterways of the country, but also in respect to the several types of vessels and the freight transported. Inland policies are peculiar in the restrictions upon the routes on which the craft may operate, and in the varying rates of premium on different streams. Some vessels carry only fire insurance, others both fire and marine insurance, and others fire, marine, and port insurance. Often no vessel insurance or insurance of any kind is carried. Some vessel owners are their own insurers, providing special reserve funds for that purpose. Insurance on vessels is usually by the year, often with lay-up clauses applicable to the period during which navigation is suspended.

Cargo insurance in some cases is entirely attended to by the vessel owner on behalf of the shipper or consignee. Generally, however, it is effected on each shipment by the shipper and continues until the vessel reaches the port of destination or for a certain time thereafter. In other cases, however, especially with reference to bulk freight, the vessel owner or owner of cargo lots takes out a blanket policy covering all shipments for a given period.

The great portion of river hulls and shipments seems to be protected by insurance. Differences in the conditions of river improvement, navigability, and river dangers are reflected in the insurance rates. In fact, the cost of insurance is often a determining factor as between rail and river shipments. The rail carrier being practically, by law, the insurer of the freight, insurance on rail freight is a negligible consideration for the shipper. But on water, and especially river traffic, this is by no means so. Instances of river insurance rates are as follows:

A company operating on Virginia and Maryland waterways reports that the insurance premium for a recent fiscal year amounted to 3.1 per cent of the gross receipts. Cargo insurance on the Red River is 0.9 per cent of the value of the goods. On the Mississippi River from Vicksburg to New Orleans cargo insurance is 45 cents per $100, or about 20 cents per bale of cotton, which must be added to the freight rate of 75 cents per bale, thus making the insurance nearly one-third of the freight.

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These high and varying rates of insurance not only increase the cost of transportation, but they also indicate the dangers of such traffic and add to the uncertainty and lack of uniformity so detrimental to shippers' interests.

There seems to be a general tendency for marine insurers to work in groups or combinations. A large proportion of the total risks assumed in the United States are taken by foreign companies. In the United States, marine insurance is largely written by corporations instead of by such associations as Lloyds, in England. There are nine important domestic companies, of which only one devotes itself exclusively to marine indemnity, the others combining fire and marine business, their fire-insurance business being larger than the marine.

TAXATION OF VESSELS AND OF NAVIGATION COMPANIES.

CONSTITUTIONAL RESTRICTIONS.

The power over interstate and foreign commerce vested in Congress, together with the specific prohibitions of the Constitution against state tonnage and customs duties without the consent of Congress, restricts the taxing power of the States over navigation as such, while leaving the States free to tax vessels like other property within their respective jurisdictions. Thus a tax on interstate traffic as such is unconstitutional, and the privilege of navigating public waters is not subject to state license tax; but States may under some conditions impose franchise taxes based in substance upon the gross receipts of transportation companies, even though part of them be derived from interstate traffic, or upon the capital stock of companies engaged in interstate commerce.

Tonnage taxes, no matter in what form, may not be imposed by a State on vessels simply because of their use of or presence in a public waterway, although where a State has made improvements in a waterway it may charge a toll for the use of those improvements, in reasonable proportion to the cost and maintenance of such improvements, even if such toll be calculated on tonnage.

Furthermore, a State or municipality may charge wharfage fees for the use of landing places provided by it, even if such fees be fixed on the basis of tonnage.

METHODS OF STATE TAXATION.

One of the common methods employed in the taxation of navigation companies appears to be an assessment of the capital stock at its market value, after deducting therefrom the assessed valuation of the corporation's vessels and other tangible property which are taxed like similar property belonging to individuals. The States using this method are Massachusetts, North Carolina, Alabama, Kentucky, Illinois, Kansas, Minnesota, and North and South Dakota. Several States, however, impose relatively light franchise or license taxes measured by the par value of the stock, and without regard to any taxes assessed upon the tangible property. These States are New Jersey, New York, Delaware, Ohio, West Virginia, Georgia, Texas, Colorado, and California. A number of others tax gross or net receipts as well as the capital stock and tangible property. These States are New York, Pennsylvania, Maryland, Virginia, and South Carolina.

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In most of the States water craft of all kinds are assessed and taxed like other personal property, either at the residence of the owners or, what is often the same thing, at the port of enrollment, registry, or license. A few States provide for taxes measured by the gross or net tonnage in lieu of other taxes on such property, on the assumption that the value of vessels is roughly in proportion to size. Vessels engaged in the foreign trade are in several States favored either with exemption from taxation or with very light taxes based upon their net earnings. Massachusetts, which formerly taxed the net earnings or dividends in such cases, now assesses the property, whether belonging to individuals or corporations, at the low rate of one-third of 1 per cent—about one-fifth of the rate of taxation on other property. A low rate of taxation on vessel property is probably of advantage to the State imposing it, because of the ease with which taxation can be evaded in respect of property so easily movable.

FEDERAL TAX.

There is no federal tax on American vessels in domestic trade. The National Government imposes a tonnage tax on vessels entered at ports of the United States from foreign ports, at the rate of 3 cents per ton in the case of vessels from near-by foreign ports and 6 cents per ton when from more distant places, but not to exceed 15 cents per ton per annum in the former case or 30 cents per ton per annum in the latter case.

Part II.—WATER-BORNE TRAFFIC.

Part II deals with the following topics:

(1) The general nature of water-borne traffic, its development, and its present importance.

(2) Through traffic of the Atlantic and Gulf coasts.

(3) Traffic at various North Atlantic ports and on tributary inland waterways.

(4) Traffic at South Atlantic ports and on neighboring rivers.

(5) Traffic on Gulf of Mexico and its tributaries, exclusive of the Mississippi system.

(6) Traffic on the Great Lakes and connecting waterways.

(7) Traffic on the Mississippi River and its tributaries and connecting canals, and the Red River of the North.

(8) Traffic on the Pacific coast and streams tributary to the Pacific.

There are very important differences between coastwise, Great Lakes, river and canal, and harbor traffic, although, owing to the incomplete nature of available statistics, these classes can not always be accurately separated.

Following is a brief statement of the results of this part of the investigation:

Domestic water-borne traffic is mainly in passengers and freight. Both the domestic express and mail movements are unimportant, and except in the coastwise trade and on the Great Lakes the same is true also of the movement of passengers. Of the total of more than 366,000,000 passengers by water reported to the census in 1906, nine-

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tenths were carried by ferryboats. Those carried by other than ferryboats were less than one-twentieth of the number of passengers carried by rail.

IMPORTANT CLASSES OF FREIGHT.

Freight moved by water includes two general classes—first, so-called package freight, usually, but not always, in bags, boxes, barrels, or other packages, and also referred to as "general merchandise," "miscellaneous merchandise," or "steamboat freight;" and, second, bulk or coarse freight, usually shipped in cargo lots, and embracing the products of mines, fields, and forests. Freight moved by water in American vessels in 1906, including harbor traffic but excluding logs and lumber rafted and floated, aggregated more than 265,000,000 tons, as contrasted with 130,000,000 reported by the census in 1889. Much the larger part of this is domestic traffic, foreign traffic being mainly carried in foreign vessels.

On the coasts and the Great Lakes there was a very marked increase in the traffic from 1889 to 1906, that of the Great Lakes having trebled and that on the Atlantic and Gulf coasts having nearly trebled. On the other hand, on the Mississippi River and tributaries there was an actual decline, and on other inland waters reported separately by the census (mostly canal traffic) there was a very marked decline during this period.

Excluding harbor and raft traffic, the water-borne traffic in American vessels for 1906 amounted to 177,519,758 tons, of which 42.6 per cent moved on the Great Lakes and 36.8 per cent on the Atlantic and Gulf coasts and rivers. Of this traffic, more than one-half the tonnage consists of certain crude minerals (coal, iron ore, stone, and sand). Other bulky mineral products, such as petroleum and other oils, cement, brick, lime, ice, phosphate rock and fertilizer, and pig iron and steel rails constitute the third largest group. Lumber and naval stores form the second largest group, and the movement of logs and timber in rafts, which is not reported, would increase the total for forest products by a large amount. Agricultural products, including grain, flour, fruits and vegetables, cotton, and tobacco, also form an important group in volume and more important if the value of the commodities is considered. The above commodities, most of which are shipped as bulk freight, together form over 80 per cent of the traffic in American vessels.

Package and miscellaneous freight comprises about one-fifth of the movement reported for 1906, and is of the greatest importance on the Atlantic and Gulf coasts, where it represents nearly 30 per cent of the volume of freight handled. The movement of this class of traffic is, however, of varying degrees of importance on all of the water routes of the country.

SPECIALIZATION OF TRAFFIC BY DISTRICTS.

Traffic is considerably specialized by districts. Coal forms the largest tonnage of any single commodity. In 1906 about 70,000,000 tons were shipped, or excluding harbor traffic over 49,000,000, nearly 30 per cent of the total freight in American vessels. The largest part of this movement is that of the North Atlantic coast, but immense

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quantities of coal are moved on the Great Lakes and also down the Monongahela, Ohio, and Mississippi rivers. Coal is also an item of large relative importance on the canals. On the Pacific coast the movement of coal is of minor importance and is declining with the increased use of petroleum for fuel purposes.

Next to coal comes iron ore, aggregating over 41,000,000 net tons in 1906. Practically the whole of this movement is on the Great Lakes, where it is more than half of the total freight tonnage carried.

Stone and sand, with other building materials, are largely carried on the Atlantic and Gulf coasts and on the rivers of the Mississippi Valley, aggregating about 15,000,000 tons in 1906. These commodities, however, are, for the most part, carried over short distances, in contrast with the long-distance movement of coal and iron ore.

Lumber still represents an important part of the movement by water in all the districts. The census figures for 1906 are over 7,000,000,000 feet, or over 14,000,000 tons, but, lacking the movement by rafts, the statistics of these movements are incomplete. The transportation of grain and flour by water is of largest importance on the Great Lakes, where two-thirds of the 7,669,000 tons of these commodities reported for 1906 were carried. The domestic trade in grain on the Lakes shows some decline in recent years. Crude petroleum is moved by tank steamers in large quantities on the Atlantic, Gulf, and Pacific coasts.

The movement of phosphate and fertilizer, cotton, fruits, vegetables, tobacco, and naval stores, is mainly on the Atlantic and Gulf coasts. Ice moves chiefly from ports on the larger rivers of Maine and from the Hudson River to New York City and southern ports. This traffic has declined, probably due to the development of ice manufactories. Considerable crude phosphate rock is shipped from Florida and South Carolina, while other fertilizer materials and fertilizers are shipped from North Atlantic ports to the South. Naval stores and cotton are shipped mainly from the South Atlantic and Gulf to northern ports. Pig iron and steel rails are items of some importance on the Atlantic and Gulf coasts and on the Great Lakes.

THROUGH MOVEMENT ON THE ATLANTIC AND GULF COASTS.

The total traffic in American vessels on the Atlantic and Gulf coasts, as reported by the Bureau of the Census for 1906, amounted to 140,512,043 tons, including harbor traffic, and to 65,360,958 tons, excluding harbor movement. Most of this is domestic traffic. The Atlantic and Gulf coasts may be divided into three districts—North Atlantic, South Atlantic, and Gulf. There is a very large through movement between these districts, and also a large local traffic within the North Atlantic district and some local traffic in the other two districts.

Four Atlantic ports, sometimes called "the Atlantic portals"—Boston, New York, Philadelphia, and Baltimore—stand out conspicuously in coastwise as also in foreign commerce. Each of these is the distributing point for an important area and also the terminal of trunk lines of railroads connecting the agricultural and manufacturing sections with the seaboard. Among other ports of importance on the Atlantic and Gulf coasts are Portland, Providence, Wilmington, Del., Norfolk, Wilmington, N. C., Charleston, Savannah, Jacksonville, Mobile, New Orleans, and Galveston.

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At the various ports traffic is specialized to a large extent. Some ports are identified with the movement of certain commodities, while at the larger ports special terminals are provided for different classes of traffic.

Coal is shipped from about a score of terminals at the five ports of New York, Philadelphia, Baltimore, Newport News, and Norfolk. Nearly 39,000,000 tons were shipped from these five ports in 1906, and 44,000,000 in 1907, over 60 per cent from terminals in and about the port of New York. Much of this moves only in the harbors and for short distances locally; but nearly half is delivered by barges at numerous points along the New England coast, over 1,000,000 tons going annually to New Haven, over 2,000,000 tons to Providence, and about 4,500,000 tons to Boston.

Lumber and naval stores are shipped from Jacksonville and Fernandina, Fla., Brunswick and Savannah, Ga., Charleston and Georgetown, S. C., Wilmington, N. C., and Norfolk and Newport News, Va., on the South Atlantic, mostly to points in the Middle Atlantic States. Receipts of southern pine at New York by water are over 450,000,000 feet. There is also a movement of eastern spruce from New England ports. Lumber is still carried to a large extent in sailing vessels, but steamships and steam-towed schooner barges are doing an increasing proportion of the business.

Cotton still occupies an important position in the Atlantic and Gulf coastwise trade. Recently there have been important changes in the relative rank of the different ports, and a general substitution of steam for sailing vessels in the carriage of this commodity. Galveston is the most important shipping point for cotton, both foreign and coastwise, but is closely followed in the coastwise trade by Savannah and Norfolk. New York is the principal receiving port, and Boston ranks second.

Crude and refined petroleum is shipped in large quantities from Port Arthur and Sabine Pass, Tex., amounting to over 10,700,000 barrels in 1906 and 8,700,000 barrels in 1907. There is also a large movement of refined oil from refineries adjoining New York and Philadelphia to New England and southern ports. Crude phosphate is shipped mostly from points in Florida and South Carolina; and fertilizers and fertilizer material are received in large quantities at southern ports from the North.

Another important movement is the interchange of general merchandise between the ports of New York, Philadelphia, and Baltimore and New England ports, and between the principal North Atlantic and the South Atlantic and Gulf ports. Other through movements include ice, fish, and granite from New England.

Trade with Porto Rico is carried on mainly from New York and New Orleans. Shipments to the United States consist mostly of sugar, with considerable tobacco and cigars and fruits. Shipments to Porto Rico include a large variety of manufactured goods.

NORTH ATLANTIC PORTS, RIVERS, AND CANALS.

Turning to the traffic within the three principal districts, above distinguished, it appears that much the greater part of this is in the North Atlantic district. This may be further divided into several subdistricts.

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THE "GULF OF MAINE"—PORTLAND AND BOSTON.

This is the great indentation between Nova Scotia and Cape Cod. It is further indented by numerous bays and harbors and tidal rivers, the most important of which are Lubec Channel, Penobscot Bay, Kennebec River, Casco Bay, Portsmouth Harbor, Massachussetts Bay (including Boston Bay), and Cape Cod Bay. There is a considerable local movement in coastwise vessels between and along these bays and rivers. Boston and Portland are its most important ports. Portland has a considerable foreign commerce in grain and flour as well as a large coastwise trade carried chiefly by sailing vessels. Its total freight tonnage (domestic and foreign) in 1906 was 2,547,000, about one-half of which was coal. Boston, the chief port of New England, is one of the most important in the country, ranking second in foreign trade to New York, and third of the Atlantic ports in domestic trade. Coal is the largest item of coastwise receipts at Boston, amounting to 4,500,000 tons annually. Lumber receipts in 1906 amounted to 165,000,000 feet, more than two-thirds from the South. Much cotton is also received, and there is an important movement of general merchandise between Boston and other Atlantic ports north and south. The total traffic in American vessels at Boston, as reported by the census for 1906, was 7,420,574 tons, mainly coastwise.

SOUTH COAST OF NEW ENGLAND.

This coast has a series of sounds and bays furnishing protected or "inside" routes from New York to various ports in Connecticut, Rhode Island, and southeastern Massachusetts, where connection is made by rail with many industrial communities. The projected Cape Cod Canal will extend the inside route practically to Boston. The "outside" route south of Long Island is used in the trade from the Middle and South Atlantic ports.

New Bedford, on Buzzards Bay, has a large trade in coal, cotton, and whale oil. Narragansett Bay has several ports of some importance; Newport has a considerable trade in coal, lumber, and fish, and is also used as a harbor of refuge for vessels and barges. The city of Fall River, at the entrance to Taunton River, has an important coasting trade, large cargoes of coal and cotton being brought to its factories and also large quantities of steamboat freight (or general merchandise) for transshipment by rail to Boston and other points. Providence is of considerable importance in the coastwise trade, with regular lines of steamers to New York and Baltimore. Coal is the most important article received, but there is also a large volume of general merchandise and a movement of lumber, building materials, oil, and oysters. The total water-borne commerce for 1906 was over 3,000,000 tons, mostly domestic.

The commerce of Long Island Sound includes most of that to and from points in Narragansett Bay and a large part of the traffic from New York to the eastern coast of New England, besides receipts and shipments at the rivers and harbors along the Sound. The Thames River is a tidal stream for a distance of 15 miles from its mouth to Norwich. New London, on this river, has a large trade in general merchandise and coal. On the Connecticut River there is considerable commerce, both in steamers and barges, as far as Hartford,

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Conn., consisting mainly of coal, lumber, building materials, and miscellaneous steamboat freight. New Haven is commercially the most important harbor on Long Island Sound, with a large trade in coal and general merchandise, and a considerable movement of lumber, oysters and shells, steel billets, and petroleum products. The water-borne commerce in 1906 amounted to 2,300,000 tons, nearly all domestic. Bridgeport, a manufacturing city, has a large carrying trade by water. Less important points include Norwalk, Stamford, and Port Chester.

PORT OF NEW YORK.

The port of New York covers an extensive area, embracing both Upper and Lower New York bays, and their connecting channels, with a total water front of about 450 miles, of which about 125 miles are available for ocean steamships. New York is by far the most important center of water-borne commerce in the United States. Its foreign commerce is many times that of any other port, and nearly one-half the total foreign commerce of the country; and the coastwise and local harbor traffic is also many times that of any other port in the United States.

According to the census report for 1906, the total traffic of New York Harbor and adjacent points is as shown below:

	Shipments.	Receipts.	Total.
Traffic in American vessels (mostly coastwise):[a]	*Tons.*	*Tons.*	*Tons.*
New York City	8,598,374	17,507,906	26,106,280
Adjacent ports[b]	6,758,978	960,350	7,719,328
Total	15,357,352	18,468,256	33,825,608
Foreign trade (estimated)	14,963,162	10,049,167	25,012,329
Harbor traffic			55,131,418
Grand total	30,320,514	28,517,423	113,969,355

[a] So far as foreign trade is carried in American vessels, there is a duplication in the total, but much the greater part of the trade in American vessels is domestic trade.
[b] Hoboken, Jersey City, Newark, Perth Amboy, and South Amboy.

NEW YORK STATE INLAND WATERWAYS.

The inland water routes of the State of New York embrace the New York State canals and the Hudson River, which connect the Lakes with the port of New York by three routes, and Lake Champlain, which serves also Burlington, Vt. The commerce of the Hudson consists principally of lumber, grain, ice, building materials, including brick, and coal. There is also an extensive passenger traffic. There has been a considerable falling off in river freight at Albany from 5,071,000 tons in 1899 to 3,326,000 tons in 1906.

Up to 1855 the traffic on the New York canals was more than twice that of the railroads crossing New York State; until 1864 it was greater than that of the railroads, and in 1872 the canal traffic was one-third of the total traffic crossing the State. Since that time, and in spite of the abolition of canal tolls, there has been a steady decline until the past ten years. During the latter period canal traffic held its own in absolute amount, but the decline in the proportion of the total amount of traffic carried by the canals has been continuous, until

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at present the New York canals carry only 3 per cent of the total traffic across New York State. The total traffic on these canals in 1907 was 3,408,000 tons. Furthermore, in the last few years there has been an increase in local and way canal freight and a decline in through traffic, so that the way traffic now constitutes more than two-thirds of the total canal tonnage. Stone, lime, and coal together form the largest proportion of the total tons moved; grain, lumber, and wood have declined, but are still among the important articles.

The commerce of Lake Champlain consists principally of coal, pulp wood, building materials, and general merchandise.

DELAWARE BAY AND PHILADELPHIA.

The commerce of Delaware Bay and its tributaries and connecting canals is exceeded by only two or three local districts in the United States. It includes the extensive trade of Philadelphia, the important traffic of Wilmington, Del., and a considerable local movement on the Delaware River, its tributary streams, and a number of private canals.

The port of Philadelphia is on the Delaware River, about 86 miles above the Capes of the Delaware. Greenwich and Port Richmond, important shipping points for the coastwise movement of coal, are within the port of Philadelphia. Marcus Hook, with a great petroleum traffic, is near by. Philadelphia is well situated with reference to waterways, and connected with many inland points, as well as domestic and foreign ports. It is one of the great exporting points and also an extensive domestic commerce. Domestic shipments on the Delaware River for 1906, as reported to the United States engineers, amounted to 12,228,000 tons, and domestic receipts by water to 8,349,000 tons, a total of 20,577,000 tons. This total involves some duplication in the case of local movements. The census report gives the traffic in American vessels at Philadelphia for 1906 at 7,934,941 tons, excluding harbor traffic.

Wilmington, Del., has some foreign trade and a considerable domestic commerce by water, while the important shipbuilding and other manufacturing interests of the city are largely dependent upon the navigation facilities.

Connecting with the Delaware River are a number of tributaries and private canals—Cooper and Mantua creeks, Mispilion and Smyrna rivers, the Morris, Delaware and Raritan, Lehigh, and Delaware Division canals, the Schuykill Navigation, and the Chesapeake and Delaware Canal connecting Delaware River and Chesapeake Bay. The traffic movement on these minor waterways is comparatively small, and that on the canals, except on the Chesapeake and Delaware Canal, has been slowly declining during the past ten years.

CHESAPEAKE BAY.

This is the largest indentation on the Atlantic coast. It is the center of a large foreign and coastwise movement converging at Baltimore, Newport News, and Norfolk, and there is also a large local movement on the bay and its numerous tributary rivers. The rivers of the eastern shore are of less general importance than those of the western, but are much used by local steamboats and small craft engaged in oyster dredging and local trade.

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Baltimore is located on the north branch of the Patapsco River about 11 miles from its entrance into Chesapeake Bay. At this port are the terminals of a number of steamship lines operating to many points on the Atlantic coast and on Chesapeake Bay and its tributary streams. In the foreign trade Baltimore ranks fourth among the Atlantic ports in the tonnage of vessels. In the coastwise trade the largest volume consists of coal shipped north and south, amounting to 3,400,000 tons in 1906 and 4,070,000 tons in 1907. There is also an important movement of package freight. The total traffic in American vessels, according to the census, was 5,437,850 tons in 1906, nearly all coastwise.

Washington is the center of a considerable trade in coal, lumber, and ice, and a market for farm produce, oysters, and fish moved over the Potomac and Anacostia rivers. Traffic on the Chesapeake and Ohio Canal consist almost entirely of bituminous coal from Cumberland, Md., to Washington. There is also some traffic on the Rappahannock and York rivers.

SOUTH ATLANTIC PORTS AND RIVERS.

The water traffic within the South Atlantic divison is small as compared with that of the North Atlantic division. The greater part of the domestic traffic of South Atlantic ports is with the North. There is little or no local movement between these ports on the open sea, but the numerous rivers, bays, sounds, and lagoons along the South Atlantic seaboard have a considerable local traffic in the staple commodities of this section, with return shipments of plantation supplies and general merchandise. The inland manufacturing towns are generally supplied with coal by rail from local southern coal fields, and there is accordingly no large water movement of coal to southern ports for inland distribution. The foreign trade is carried very largely in tramp steamships, but the coastwise trade is sufficiently regular and large to employ regular lines of steamers to northern ports.

Norfolk and Newport News, at the southern end of Chesapeake Bay, near Hampton Roads, have a large and varied commerce, including important shipments of coal. The total water-borne commerce of Norfolk reported to the United States engineers for 1905 was 10,914,000 tons, and for 1906, 15,662,000 tons. The traffic in American vessels at Norfolk and Newport News, according to the census of 1906, was 10,488,576 tons, practically all coastwise.

Wilmington, the chief port of North Carolina, is on the Cape Fear River, about 27 miles above its mouth. Its total commerce by water for 1906 was about 800,000 tons, including logs and lumber rafted; traffic in American vessels was 267,139 tons.

The two principal ports of South Carolina are Georgetown, on Winyah Bay, and Charleston, at the confluence of Cooper and Ashley rivers. The commerce of Georgetown for 1906 amounted to 393,000 tons. Charleston has some foreign and considerable coastwise trade, but has declined as a cotton port. The foreign and coastwise commerce for 1906 amounted to 835,000 tons; traffic in American vessels, 718,680 tons.

Savannah, on the Savannah River, about 15 miles above the entrance, is the principal port of Georgia, and is one of the most im-

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portant South Atlantic seaports for the shipment of cotton, lumber, and naval stores, which are received from the interior by rail and to some extent by river. The traffic in American vessels in 1906 was 1,490,363 tons. Brunswick, Ga., is also an important shipping point for lumber.

On the Atlantic coast of Florida are the two important ports of Fernandina and Jacksonville, with a total commerce by water in 1906, as reported to the United States engineers, of 955,000 and 2,115,000 tons, respectively. The census gives the traffic in American vessels at Jacksonville at 993,566 tons. At the southern end of the peninsula there is a small movement centering at Miami.

RIVERS AND OTHER INLAND ROUTES.

There is considerable traffic on the James River. Through the Dismal Swamp and Albemarle and Chesapeake canals there is some movement of forest products and other traffic between Norfolk and the rivers and sounds of North Carolina. There is also considerable local traffic on the tributaries of Albemarle and Pamlico sounds and some on the Cape Fear River. In South Carolina there is a local movement of some importance on the Waccamaw, Pedee, and Santee rivers. There is also some local traffic, mostly of lumber, on the Savannah, Altamaha, and Ocmulgee rivers in Georgia, and a considerable movement on the St. Johns River in Florida. The inside coast routes have but little traffic.

GULF PORTS AND RIVERS, EXCLUSIVE OF THE MISSISSIPPI.

PRINCIPAL GULF PORTS.

The chief Gulf ports, in the order of importance, are New Orleans, Galveston, Mobile, Port Arthur, Pensacola, Tampa, and Key West. Each has considerable export and coastwise trade moved by steamship lines and sailing vessels. Of coastwise shipments, the greater part are to northern ports, the remainder representing a local movement between Gulf ports.

Several steamship lines run from Mobile to ports in Central America, Mexico, and Cuba, and a number of tramp steamers to Europe. A steamship line operates between Mobile and New York, and several local lines run to neighboring Gulf ports and river ports, including Montgomery. Important bulk commodities handled at Mobile are lumber and timber, cotton, and coal. The total commerce reported by the United States engineers for 1906 was 1,373,000 tons, of which 302,000 tons were coastwise. Traffic in American vessels was 363,000 tons, according to the census report.

New Orleans is on the Mississippi River about 100 miles from the Gulf. The port facilities for handling cargoes are excellent. Rail lines from all directions converge here, and there are regular lines of steamers to Tampa, Baltimore, and New York, and also to Mexico, Central America, Panama, Habana, Porto Rico, and European ports, besides many tramp vessels. In the foreign trade, New Orleans is an important point of import for the products of Central and South America and the West Indies. In exports it is also of much importance, particularly in the cotton trade. New Orleans is a natural

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port of export for cotton and grain. In the coastwise trade shipments are made up of cotton, rice, citrus fruits, and other agricultural products, lumber, sugar, molasses, etc., the most important traffic being with New York. The total water-borne commerce of New Orleans (foreign, coastwise, and river) for 1906 was 5,702,000 tons, three-fifths of which was foreign trade. The coastwise movement reported to the United States engineers amounted to 694,000 tons. According to the census, the foreign and coastwise traffic in American vessels at New Orleans for 1906 was 1,924,484 tons. The river commerce of New Orleans will be considered in connection with the Mississippi River.

Galveston is the principal port of Texas, and the second Gulf port in importance. According to the United States engineers, it has the largest coastwise trade of any of the Gulf ports, amounting in 1906 to 832,000 tons. The census reports the traffic in American vessels for 1906 at 1,695,897 tons. Several important lines of steamers run regularly to Atlantic ports, and it also has a large foreign trade in cotton, cotton-seed products, sugar, coal, and general merchandise.

TRIBUTARY RIVERS.

The maritime commerce of the Gulf ports is fed to some extent by tributary rivers. Of these, the most important are the rivers of the Alabama system, including the Mobile, Alabama, Coosa, and Tombigbee. Other Gulf tributaries with local traffic of some importance include the Withlacoochee, in Florida; the Apalachicola and its tributaries, in Florida and Georgia; the Pascagoula, Leaf, and Chickasahay, in Mississippi; the Chefuncte and Calcasieu rivers and bayous Plaquemine and Teche, in Louisiana, and the Neches, Sabine, and San Jacinto rivers, in Texas.

THE GREAT LAKES AND CONNECTING WATERWAYS.

The principal characteristics of Lake commerce are the preponderance of eastbound over westbound shipments and the fact that the traffic is mainly in a few commodities—iron ore, grain, coal, and lumber. There is a considerable movement of miscellaneous and package freight, both local and through, but it is small compared with the enormous bulk-freight traffic in the crude products of contiguous mines, forests, and grain fields.

Through traffic constitutes the greater part of the total freight movement. The main course of this lies between the western extremity of Lake Superior and the southern shore of Lake Erie.

The Lake traffic was not reported as a whole prior to 1889, when, according to the Census, the domestic traffic amounted to 25,266,974 net tons. The domestic traffic amounted to 45,000,000 tons in 1901, and in 1907 to more than 80,000,000 (shipments 83,507,000 and receipts 81,124,000 net tons).

MOVEMENT OF COMMODITIES.

Iron ore and coal form by far the greater part of the Lake traffic, and furnish together 98 per cent of the total increase from 1905 to 1907. The movement of lumber during these years has declined in

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importance; other traffic, outside of ore and coal, has remained about stationary.

Since 1890, with the development of the Lake Superior mines, the United States has taken first rank among the world's iron producers. Of the total domestic production of iron ore, approximately 80 per cent was transported by way of the Great Lakes (41,000,000 net tons in 1906 and 45,500,000 net tons in 1907), constituting in some years more than half of the total domestic Lake traffic.

Next in volume to iron ore, and first in the westbound Lake traffic, is the westbound movement of coal. This was over 21,000,000 tons in 1907, representing about a fourth of the domestic Lake traffic.

In the movement of flour and grain (eastbound) there is active competition between the Lake and all-rail routes, and with the decline in export trade the domestic movement on the Lakes has remained practically stationary in recent years, at about 150,000,000 bushels of grain and 1,300,000 tons of flour. There has been an increase of traffic from American ports to Canada and also between Canadian ports.

The traffic in logs and lumber is decreasing in volume and still more in relative importance. Nevertheless, it still constitutes one of the leading items.

Some of the less important forms of traffic are the movement of copper, salt, pig iron, and package and miscellaneous freight. About 100,000 tons of copper ore are annually shipped, mainly from the copper district in the Upper Peninsula of Michigan. Salt is shipped by Lake in considerable quantities from Manistee and Ludington, Mich., and in smaller quantities from Buffalo and other points. Pig iron moves in small lots between a considerable number of ports. Package and miscellaneous freight forms about a tenth of the total traffic.

TRAFFIC BY LAKES AND PORTS.

Lake Superior shows the largest volume of shipments of any of the Great Lakes, domestic shipments aggregating over 40,000,000 tons in 1906. About 65 per cent of the total traffic of the Lakes passes in or out of Lake Superior through St. Marys Falls canals. Lake Erie has the largest receipts (43,600,000 tons in 1906 and 47,000,000 in 1907 in the domestic traffic), is second in volume of shipments (18,450,000 tons in 1906), and has the largest proportion of the total traffic. Lake Michigan ranks third, but has the largest amount of local traffic.

Notwithstanding the large number of Lake ports, about a dozen ship and receive 80 per cent of the water-borne traffic. Duluth-Superior is the most important port for shipments and has the largest water-borne traffic of any of the Lake ports, aggregating over 29,000,000 tons in 1906, mainly ore, grain, and coal. Chicago and Milwaukee are among the leading ports, both for shipments and receipts. The Lake commerce of Chicago amounts to about 10,000,000 tons annually, and that of Milwaukee to 6,000,000 tons. Buffalo and Cleveland are also ports of first importance, both in the volume and in the variety of their commerce, and Buffalo has the largest receipts of any of the Lake ports. The Lake commerce of Buffalo for 1906 exceeded 15,500,000 tons (domestic traffic 14,345,000 tons), and, including canal traffic, the total water-borne commerce of Buffalo

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was over 17,320,000 tons. The Lake commerce of Cleveland for 1906 was 12,247,000 tons (domestic traffic 11,670,000 tons). Other important but more specialized ports include Two Harbors, Ashland, and Marquette, on Lake Superior, and Escanaba, on Lake Michigan, for shipments of ore; Toledo, Ashtabula, Lorain, Conneaut, and Erie, on Lake Erie, for receipts of ore and shipments of coal, and Tonawanda for receipts of lumber.

MISSISSIPPI RIVER AND TRIBUTARIES.

This is the greatest of our inland-river systems, and belongs in a class by itself. It includes not only the Mississippi itself, but also the Ohio, Missouri, Illinois, Arkansas, Ouachita, Red, and Yazoo rivers. with their tributaries, together with a number of other rivers of minor importance. The state canals of Ohio and Illinois are also connected with this system.

The commerce of these various waterways has not kept pace with the general industrial progress of the Middle West. The methods of competition of railroads and the limitations imposed in the competition of boat lines with railroads by the physical characteristics of the rivers in their present condition are the prime causes that have contributed to the decline of river traffic. The boat lines have been handicapped in their competition with rail carriers by the tortuousness of the channel and by the limited and varying depths, causing at times a practical suspension of traffic. They have made little advance in methods for a long time, while the railroads have made important improvements both in physical conditions and in business methods. These improvements, adapted to the changing needs of commerce, in the absence of corresponding improvements in the rivers, have resulted disastrously to boat lines. To-day the principal long-distance shipments by river consist of coal from the Ohio and its upper tributaries to lower Ohio and Mississippi River points, and of logs, lumber, and railroad ties on the whole system, the bulk of the traffic moving downstream.

OHIO RIVER AND TRIBUTARIES—PITTSBURG.

The Ohio with its tributaries has now the most important river traffic in the country. Coal carried in barges from the Monongahela and other tributaries forms the largest part of this movement. Lumber, sand, and gravel are other bulk commodities moved in barges. Logs and timber are rafted in considerable quantities. There is also a considerable amount of miscellaneous and manufactured articles transported in mixed cargoes on packet steamers. In the latter movement local traffic is relatively more important than formerly, owing to the disappearance of through packet lines.

Pittsburg has now the largest river commerce of any inland city in the country. Coal from the Monongahela is received in large quantities, and there is a large harbor movement of sand. Receipts and shipments by river for 1906, according to the Census, amounted to 6,854,575 tons, and including harbor traffic to 8,956,697 tons. Reports to the United States engineers show a total traffic in Pittsburg Harbor for 1906 of 12,927,975 tons.[a] At Cincinnati receipts and shipments

[a] This probably includes the movement of coal from the Monongahela River to points on the Ohio below Pittsburg, which simply passes through Pittsburg Harbor.

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by river for 1906 amounted to 2,363,215 tons; at Louisville to 1,203,727 tons, the total river traffic at Louisville being reported to the United States engineers at 1,436,674 tons. Other places of importance are the Ohio and its tributaries include Wheeling, Parkersburg, Marietta, and Evansville; Nashville, on the Cumberland River; Knoxville, Chattanooga, and Florence, on the Tennessee River, and Cairo, at the junction of the Ohio and Mississippi. Traffic on the Ohio state canals is unimportant.

The traffic of the Ohio River and its more important tributaries for 1906 is shown in the following table:

Rivers.	U. S. Census.[a]		U. S. engineers,[b] total traffic.
	Shipments.	Receipts.	
Monongahela	8,925,923	545,716	11,817,128
Muskingum	13,826	11,073	28,433
Little Kanawha	11,239	6,953	70,289
Kanawha	975,031	63,832	1,327,703
Big Sandy	1,776	4,887	206,452
Kentucky			184,244
Green and Barren	305,144	80,902	416,908
Wabash	42,427	30,537	
Cumberland	348,697	178,951	558,250
Tennessee	678,501	472,759	1,578,760
Ohio	3,142,097	12,296,037	11,427,784
Other[c]	782,144	345,299	
Total	15,226,805	14,036,946	

[a] Excluding logs and rafted lumber. [b] Including logs and lumber.
[c] Allegheny and Kentucky rivers.

The statistics of the United States engineers give the total traffic on each river, and a total of these figures would duplicate the traffic moving from one stream to another. Shipments and receipts on the whole Ohio system represent practically the same traffic. The total shipments should indicate the total traffic of the Ohio system, but the census figures do not include the movement of rafted logs and lumber, and including this and harbor traffic (2,354,000 tons), the total shipments on the Ohio and tributaries were probably about 20,000,000 tons.

The census figures show a considerable decline on practically all of these rivers except the Monongahela from 1889 to 1906, and a small decline on the Ohio system as a whole; but the principal decrease indicated is in lumber, the rafted movement of which was partly reported in 1889 and not in 1906. Including coal, the total traffic has probably increased, but shipments of miscellaneous merchandise decreased from 2,819,000 tons in 1889 to 1,314,000 tons in 1906.

UPPER MISSISSIPPI,—ST. LOUIS.

The commerce of the upper Mississippi and its tributaries is relatively unimportant and declining. It consists mainly of local traffic, largely of rafted logs and lumber, and of sand. Traffic on the canals connecting the Mississippi with the Great Lakes is even less important. St. Louis is a converging point for traffic from the upper Mississippi and to a slight extent from the lower Mississippi, the Missouri, the Illinois, the Ohio, the Cumberland, and the Tennessee rivers.

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But river commerce at St. Louis has declined steadily during the past fifteen years. The St. Louis Merchants' Exchange reports shipments and receipts of 1,266,000 tons in 1890, of 757,000 tons in 1900, and only 417,000 tons in 1906. The census reports the total shipments and receipts in 1906 as 743,981 tons, including 309,000 tons of sand and stone. The harbor traffic is reported at 969,000 tons.

LOWER MISSISSIPPI,—MEMPHIS AND NEW ORLEANS.

This includes the river from St. Louis to New Orleans. Here the most important through traffic is coal from the Ohio. At Memphis, Greenville, Vicksburg, Natchez, and other places there is some river traffic in coal, lumber, and plantation products and supplies. Memphis is one of the few ports on the Mississippi showing an increase in river traffic in recent years. The traffic in 1906 was 857,000 tons, and that at Vicksburg 375,000 tons. At New Orleans the receipts of bituminous coal by river from the Ohio are estimated at about 1,200,000 tons annually. Cotton, cotton seed and its products, sugar, molasses, and rice are also received at New Orleans from various points on the lower Mississippi and other streams in this territory. There is also considerable traffic in crude petroleum from Louisiana, on the lower Mississippi. The various short canals more or less directly connected with the New Orleans river trade are commercially of comparative unimportance. The total river traffic at New Orleans in 1906, according to the census, was 1,144,113 tons, and according to reports to the United States engineers was 1,666,000 tons.

Below is given a summary of the traffic reported on the several sections of the Mississippi and some of its tributaries (other than the Ohio) for 1906:

Rivers.	U. S. Census.[a]		U. S. engineers, total.[b]
	Shipments.	Receipts.	
	Net tons.	*Net tons.*	*Tons.*
Upper Mississippi	595,885	597,025	5,282,319
Illinois	105,826	105,002	.....
Missouri and other tributaries	1,056,390	1,051,474	573,348
Total	1,758,101	1,753,501	5,855,667
Lower Mississippi	[c] 2,329,350	3,487,137	.....
St. Louis to Cairo	.....	.....	458,016
Cairo to Memphis	.....	.....	1,719,893
Memphis to Vicksburg	.....	.....	2,355,901
Vicksburg to New Orleans	.....	.....	2,554,336
St. Francis	[d]	[e]	151,015
White	43,933	25,433	127,812
Arkansas	24,994	35,871	104,593
Yazoo	108,357	62,325	227,611
Ouachita and Black of Louisiana	25,136	18,998	171,952
Red	14,417	8,481	112,273
Other rivers	.....	[c] 102,401	.....
Total	2,546,187	3,740,646	.....

[a] Excluding logs and rafted lumber.
[b] Including logs and lumber.
[c] Including the Atchafalaya, Black of Arkansas, Black Bayou, Lafourche, Macon Bayou, St. Francis, and Tensas.
[d] Included in lower Mississippi.
[e] Included in other rivers.

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The traffic reports to the United States engineers give each stream and the sections of the lower Mississippi separately, and a total of these would include duplications to a large extent. The Census figures, on the other hand, do not show the movement of logs and rafted lumber, while the shipments on the lower Mississippi do not include the coal movement from the Ohio. The shipments on the upper Mississippi and the receipts on the lower Mississippi indicate a total traffic on the Mississippi of 5,500,000 tons, excluding logs and rafted lumber and harbor traffic. Including rafts and harbor traffic, the total movement on the Mississippi and tributaries, exclusive of the Ohio system, is probably about 12,000,000 tons.

For the entire Mississippi system, the total shipments and receipts from one port to another, according to the Census as shown below, amounted to 19,531,093 tons in 1906. Including rafts, the movement would be about 25,000,000 tons, and including also harbor traffic (5,190,291 tons) the total would be about 30,000,000 tons.

	Shipments.[a]	Receipts.[a]	Harbor movement.
	Net tons.	*Net tons.*	*Tons.*
Ohio River system	15,226,805	14,036,946	2,354,147
Upper Mississippi system	1,758,101	1,753,501	482,099
Lower Mississippi system	2,546,187	3,740,646	2,354,054
Total	19,531,093	19,531,093	5,190,291
Car ferries (estimated)			6,905,597

[a] Excluding rafts.

The Census reports show a large decrease in traffic on both upper and lower Mississippi and for the whole Mississippi system from 1889 to 1906. The extent of this decrease is, however, somewhat exaggerated by the omission of rafted logs and lumber from the statistics of 1906, although these were partially included in 1889, and the largest decrease indicated is in the movement of lumber. But the movement of grain, cotton, and miscellaneous merchandise has fallen to small proportions; and while coal, petroleum, and sand have increased, the total traffic on the whole system is undoubtedly a good deal less than in 1889. The most important increase has been the coal traffic of the Monongahela; there has been an increase of miscellaneous freight on the Cumberland, the Tennessee, and the Yazoo rivers, and the total volume of traffic on the Yazoo has increased to some extent.

PACIFIC COAST AND TRIBUTARIES.

The traffic of the Pacific Coast States is still mainly in raw materials and agricultural products, such as wheat and its products, barley, live stock, fruits, hops, and the products of forests and streams. A recently developed traffic has followed the discovery of oil fields in southern California. Generally speaking, the articles mentioned, with the wool, live stock, and minerals of the Rocky Mountain States, constitute most of the traffic in this territory, either coastwise, by river, or by rail.

The important political events of the past few decades have increased considerably the water-borne commerce of the Pacific coast. The mining and commercial development of Alaska, as well as the demand on the part of oriental countries for the products of the West,

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have aided in this development, as have also the extension of railroad facilities and the introduction of new crops and industries. One serious drawback has been the scarcity of coal, which is now being partially met by the use of oil for fuel purposes.

The principal bulk coastwise shipments are products of the forests and petroleum. Lumber is moved in large and increasing quantities from Puget Sound, the Columbia River, and the coasts of Washington, Oregon, and upper California. Cargo shipments from Washington and Oregon have increased from 398,000,000 feet in 1894 to 1,443,000,000 feet in 1907; and, including upper California, the total cargo shipments for 1907 were 1,880,000,000 feet. Most of this movement is coastwise.

Petroleum is shipped, mainly in tank steamers, from Port Harford and other points between San Diego and San Francisco to coast points and Hawaii. Shipments in 1906 amounted to nearly 11,000,000 barrels, or about 1,700,000 tons. Some grain moves coastwise from Oregon and Washington to San Francisco, receipts at the latter point amounting to 3,848,000 bushels in 1906 and about the same in 1907. There is a considerable movement of coal by water from Puget Sound and Coos Bay (Oregon) to other Pacific coast points, largely to San Francisco, in vessels employed also in carrying lumber and general merchandise, but there is no regular and exclusively coal carrying fleet. Shipments of coal from Seattle and Tacoma amounted to 605,000 tons in 1906 and 701,000 tons in 1907. Receipts of coal at San Francisco (including imports from British Columbia and Australia) amounted to about 800,000 tons in each of these years.

Traffic between the Pacific Coast States and Alaska and, of course, Hawaii, is carried by water. Most of the trade to Alaska is from Puget Sound ports, steamship companies operating principally from Seattle. The largest share of the Hawaiian trade is from San Francisco, but there is also a considerable amount from Puget Sound and some vessels from the Atlantic coast.

There is a considerable trade between San Francisco and Puget Sound and the Philippine Islands carried by way of Hongkong, as there is no direct line from the Pacific coast to Manila; but the larger part of the trade with the Philippines is from New York, and a notable part of the return movement comes to Boston.

The four leading ports on the Pacific are San Francisco, Portland, Seattle, and Tacoma. Each is the center of numerous water routes and the terminus of transcontinental lines of railroad. From San Francisco the shipments in American vessels in 1906 amounted to 1,656,614 tons, from Seattle 856,988 tons, from Portland 492,573 tons (total domestic traffic by water 648,497 tons), and from Tacoma 270,256 tons. On the Pacific coast generally a larger proportion of the trade in American vessels is foreign trade than on the Atlantic coast. Grays Harbor and Humboldt Bay are important lumber shipping points; Port Harford, in San Luis Obispo Bay, is an oil port; the ports of Los Angeles receive large quantities of lumber and general merchandise, and San Diego has a considerable trade by water.

There is some local traffic on several groups or systems of rivers on the Pacific coast. On the tributaries of Puget Sound there is a large local movement of logs, aggregating 1,200,000,000 feet in 1906; and

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a small amount of local traffic of other kinds. On the Columbia River there is some traffic on the upper river and tributaries, and a larger river commerce below Portland, including an extensive movement of logs. On the short rivers and bays along the coast of Washington, Oregon, and upper California, there are large numbers of logs moved and a small amount of general traffic. The most varied river traffic is on the rivers of central California, where there is a considerable movement of grain, flour, and general merchandise, centering at Sacramento and Stockton.

Part III.—PORT TERMINALS.

The control of port terminal facilities forms the key to the important question of effective competition with railroads on the part of water lines; but to a very great extent the water fronts of important ports, or the most available parts thereof, are so controlled by railroads and their allied water lines as practically to eliminate effective competition. In many cases the railroads have acquired water-front property by purchase or condemnation because it was the most available location for their tracks and terminals, or because they possessed greater foresight than other investors as to the potential value of such property; in other cases, however, railroads have gained possession of valuable water fronts by encroachments, which have sometimes ripened into legal titles through the neglect of municipalities or other riparian owners.

Railroad control of city water fronts is very extensive. An important case of such control is the occupation of the lake frontage of Chicago by the Illinois Central Railroad. Practically all the water lines operate in the narrow and tortuous Chicago River, impeded by bridges above and until recently by tunnels below. Among other noteworthy cases of railroad control of a city's water front may be mentioned Buffalo, N. Y.; Cleveland, Ohio; Jersey City, N. J.; Norfolk, Va.; Mobile, Ala.; Oakland, Cal.; and Tacoma, Wash.; while at many points along the Ohio and Mississippi rivers the railroads occupy long stretches of water front, including not only the areas needed for their own terminal facilities, but miles of river bank which, but for the adverse possession of the railroads, might readily be acquired and utilized by their would-be competitors by water.

Control of terminal facilities by railroad and industrial interests and steamship lines is so extensive at some ports as to make it difficult for independent boats or occasional sailing vessels to obtain landing privileges. In some cases, for example, a particular navigation line has acquired all of the water front affording direct access to rail terminals, or a number of lines may together control all the conveniently available wharves. At several ports on Long Island Sound the several steamboat lines controlled by the New York, New Haven and Hartford Railroad have acquired possession of the available wharves to such an extent that independent lines and even shippers have experienced great difficulty in obtaining terminals.

It is not necessary, however, for the railroads to own great stretches of water front in order to control the terminal situation at important ports. So far as through traffic is concerned, a railroad need only

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have a wharf at the point of transfer between rail and water carriers in order to have a decisive advantage over its competitors by water. It is not the wharf alone that gives this advantage; a wharf connecting a rail line and a water line is of much more importance than a wharf without rail connections. Railroads having wharves in such strategic positions commonly "absorb" the wharfage charges in their through rail-and-water rates, or, in other words, make no additional charges for wharfage on through traffic going or coming over their own lines. A water line can not so well afford to offer free wharfage, especially if it has to lease a wharf or pay wharfage charges itself; and in any case, unless the wharf has rail connections, the freight must be taken to and from the wharf either by lighters or by trucks, involving additional expense. Where a railroad comes down to the wharf, lighterage is unnecessary, in the case of goods going over that line at least; and as railroads commonly have switches to many of the important industries along their lines, freight cars can usually be left at the door of the factory, mill, or jobbing house to which it is consigned. Thus, railroad control of terminals results in a decided disadvantage to independent all-water lines, and in procuring the shipment of freight as far as possible by rail, even when it could go partly to its destination by water.

A port which allows its wharves to fall mainly into the hands of railroads is likely to find its local shipping business injured thereby; for railroad control of water terminals at a port apparently tends to result in their use for transfer of through freight between cars and vessels to the exclusion of business originating at or destined to the port itself. A legislative commission recently appointed to investigate conditions at the port of New Orleans, after visiting the ports of Galveston, Mobile, Pensacola, and Savannah, at all of which the terminals are in the hands of railroads and private owners, reported that the shipping business at all these ports is simply a matter of transferring freight from cars to ship; and that the local trade by water of Galveston and Savannah is gone. An extreme case of the use of terminal facilities by a railroad to secure traffic for its line, with the result of creating a monopoly, is that of a pier at Galveston erected by the Southern Pacific Terminal Company (affiliated with the Southern Pacific Railroad) and leased to a shipper of cotton-seed products, one of the conditions of the lease being that the lessee must route all his shipments over the lines of the terminal company. The lease being at a fixed rental per annum, when the lessee's shipments exceed a certain amount a year his terminal charges per hundred pounds were less than the regular wharfage charge to other shippers, and the result was practically to center in him all the cotton-seed product export business of Texas and adjoining States.

The Interstate Commerce Commission has declared this arrangement unlawful in that it gave the lessee undue preference and advantage in exempting him from the published wharfage charges and giving him the exclusive use of wharf space such as other shippers could not obtain. Another way in which railroads controlling wharves have sometimes used them so as to secure undue advantages is by denying their use to independent or competing vessels, even on payment of wharfage charges, while granting their use free of charge to vessels handling traffic in connection with the controlling railroad

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on through bills of lading, and so bringing traffic to that road. To some extent such discriminations have been declared illegal by the courts, which have held that wharves, at least when they are railroad terminals, are so affected with a public interest that their owners are bound to extend their facilities to all on equal terms, if they hold themselves at all as public wharfingers. This rule, however, will not prevent a railroad owning a wharf from using it solely for its own carrying business in connection with its own lines;[a] nor has it been so universally applied as wholly to do away with the granting of exclusive wharf privileges to steamship lines. At Boston each of the great ocean steamship lines has the exclusive use of a pier belonging to a railroad company; while at Philadelphia the complaint is made that the railroads will not allow lighters to come to their piers, but practically require all the goods coming to their piers to go over their own lines.

There are several ports on the Great Lakes and a few on the Atlantic coast north of Savannah at which the terminals are controlled by railroads and used almost wholly for the transfer of through freight between cars and vessels; but at some of them, especially the smaller places, the question of decay of the local trade has never arisen because the shipping industry has been created by the railroads in connection with their through business. There are advantages both to the railroads and to the general public in the establishment of such transfer terminals at points outside of the large cities, where the price of land is low enough to make plenty of warehouse room feasible, and where, by avoiding the congested city terminals, transfers can be effected with much greater expedition. Congestion of traffic is complained of at many ports as an evil of no small magnitude, and in several cases steps are now being taken by public or private agencies to increase the available wharf facilities.

PUBLIC OWNERSHIP AND CONTROL OF WATER FRONTS AND WHARVES.

Public ownership of wharves is much less common in this country than in Europe, but a number of American cities have owned wharves from early days, and in recent years several cities have more actively undertaken the development of the commercial water front.

Public ownership of the water front alone is not necessarily effective in preventing its practical control by transportation interests. The constitution of the State of Washington provides that the land below the line of high tide shall never be alienated by the State. Yet there is no indication in the data available on this point from the State of Washington that this has prevented the railroads from getting large control of the commercial water fronts; every indication points to extensive railroad control. The ineffectiveness of the Washington system is perhaps due in part to the provision of law which gave riparian owners preference in granting leases of water-front areas, and partly, no doubt, to the provision which limits the rentals to an amount less than the real rental value of such locations.

[a] Dutton *v.* Strong, 1 Black, 23; Indian River Steamboat Company *v.* East Coast Transportation Company, 28 Fla., 387; West Coast Naval Stores Company *v.* L. & N. R. R. Co., 121 Fed. Rep., 645.

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Even public ownership of wharves and other improvements on the water front is not always effective as a means of retaining actual control. The New York system of partial municipal ownership has been criticised on the ground that by leases of wharves for long terms of years the city practically loses control of important parts of its wharf system, so that vessel owners who neither own nor lease wharves have to obtain landing privileges from the lessees.

Short-term leases are not commonly considered practicable where the lessee is expected to erect expensive improvements, such as fireproof sheds, but provision is sometimes made for compensation for such improvements, after allowing for depreciation. Another plan permitting short leases is the construction of all improvements on public wharves at public expense; though in some cases this may not be financially feasible. San Francisco partly solves this difficulty and also avoids losing actual control of its water front by leasing each new wharf for a short period, never exceeding fifteen years, to such bidder who will take a lease for the smallest number of years, the said bidder to construct at his own expense a wharf of a specified character. At the expiration of the term agreed upon the wharf reverts to the public and becomes a public wharf. On the whole the system seems to have proved satisfactory.. At any rate, the public is gradually acquiring valuable wharf properties, practically without expense in the long run. Bond issues are sometimes necessary at San Francisco as elsewhere, for the lessees pay their rentals in annual instalments extending throughout the term of their leases.

COORDINATION OF TERMINAL FACILITIES.

In several of the most important cities of the United States, local shippers are handicapped by lack of convenient access to rail and water transportation facilities, more especially the latter, owing to the haphazard distribution of terminals and the lack of coordination between them. Such disadvantages may more than offset the advantage of nearness to the place of production or sale. Many large cities have belt or terminal railways connecting the trunk railroad terminals; and New Orleans has just completed a public belt railroad connecting both rail and water terminals which is to be operated by public officials. This belt line consists of more than twenty miles of double track, with switches at all the wharves, all the freight depots, and all the more important industries, thus eliminating drayage to the greatest possible extent. A public belt railroad is also operated on the San Francisco water front. Much more common are switching tracks controlled either by a wharf company, as at Galveston and at the Bush terminal in South Brooklyn, or by a trunk railroad, as at Boston. At Philadelphia and Buffalo, however, special precautions have been taken to prevent the terminal railroads connecting the wharves from falling wholly into the control of any single railroad; at Philadelphia, by turning a majority of the stock over to the board of trade and the commercial exchange, as trustees for the commercial interests of the city; and at Buffalo, where the terminal line is owned jointly by two trunk lines, by a franchise requiring equal facilities to be provided for all companies and individuals desiring them.

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MECHANICAL LOADING AND UNLOADING APPLIANCES.

Bulk cargoes consisting of such homogeneous materials as coal, ore, or grain lend themselves most readily to mechanical loading and unloading; and it is where such special traffic is greatest in amount that mechanical appliances for loading and unloading vessels find their fullest development. It is said, probably without exaggeration, that no other traffic in the world has arrangements for handling so perfect as has the iron-ore traffic on the Great Lakes and the connecting railroads. Ore trains direct from the mines are run out on high piers or trestles at Duluth and other upper lake ports and unloaded by gravity into pockets from which the ore flows into the steamers alongside the piers. At the ports of discharge on the lower lakes the ore is lifted from the holds of the vessels by electric cranes carrying several tons at a load, and often deposited directly in railroad cars waiting to take it to its destination. Thus vessels carrying over 10,000 tons of ore are often loaded in a few hours, and unloaded in less than a single working day. A vessel often receives its return load of coal without changing its berth, both the loading and the unloading being again effected by mechanical devices. At the coal ports on the Atlantic coast and along the Ohio River and its tributaries coal is loaded mainly by gravity from "tipples" or trestles extending out over the water, while at Cincinnati and New Orleans it is unloaded and elevated to cars or steamships by mechanical means.

Very complete appliances for loading and unloading grain at points of transfer between rail and water lines are provided by the grain elevators, which serve also as storage warehouses for longer or shorter periods, and have machinery for mixing and often for cleaning grain.

The ore trestles at the head of the lakes are owned by the railroads, as are also the receiving appliances at lower lake ports except where industrial concerns are located on the lake front and have their own unloading machines.

Coal tipples in the mining regions are commonly owned by coal-mining companies; those at ports of transshipment, on the Great Lakes and elsewhere, either by coal companies or by railroads; while at distributing points the coal is unloaded mainly at wharves belonging to coal companies, some of which, however, are themselves controlled by railroads.

Grain elevators are owned sometimes by railroads and sometimes by grain dealers. In many cases railroad elevators are leased, and are operated by grain dealers as lessees. At Buffalo there is an elevator pool composed of the elevators having both rail and water connections, except those belonging to railroad companies, which latter were active in its organization, but were forced out by the amendment to the interstate commerce act extending to terminal facilities the prohibition against pooling. The railroads still act in harmony with the pool, however, and there seem to be good reasons for believing that the pool is really an agency through which the railroads practically control the elevator situation at Buffalo.

At New Orleans the United Fruit Company has several machines for unloading bananas from its vessels by means of endless canvas belts, consisting of a series of pockets, which can also be employed in

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loading or unloading any merchandise put up in sacks or small packages.

In marked contrast with the complete arrangements provided by railroads, coal companies, and other concerns for handling ore, coal, grain, and tropical fruits, is the almost complete lack of mechanical appliances for loading and unloading cargoes of general merchandise at American ports, whether the wharves are under railroad, private, or public control. In loading or unloading a large general cargo, the vessel's own steam winches are employed, together with skids, to deposit the freight on the wharf at the vessel's side or to lift it from that point into the vessel's hold; but the movement of freight on the wharf itself is usually effected with hand trucks. At European ports it is common to find the wharves equipped with powerful cranes moving on tracks paralleling the water's edge, so they can be brought into requisition at any point. There is an obvious advantage in the use of such machinery on the wharf instead of the vessel's own winches, because the wharf machinery has a longer reach landward, and can be used in loading railroad cars direct from the vessel or in storing freight in a warehouse. That American stevedores are content to do with comparatively primitive arrangements is one of the most curious facts connected with American shipping.

Along the Ohio River the rise and fall of the water is too great to admit of the use of fixed wharves, and their place is therefore taken by floating wharf boats which rise and fall with the water. To the inconvenience of this kind of landing is added, at most points, the difficulty of hauling freight up the steep banks of the river. The same is true of some places on the lower Mississippi.

PORT CHARGES.

At New York and some other ports complaints of high port charges are frequently heard. At New York, indeed, the decline of commerce of the port is attributed largely to the high charges for pilotage, towboat charges, wharfage, lighterage, and the expense of discharging cargo. The United States tonnage tax on vessels from foreign ports, together with custom-house and quarantine charges, and the local health officer's and port warden's fees, make up the other port charges, commonly so called. It is difficult to keep wharfage charges low where land, and consequently wharf room, is as valuable as it is on Manhattan Island.

Where the wharves are publicly owned, as a rule, they are not made a source of revenue to any considerable extent, the usual policy, in theory at least, being to reduce the wharfage charges to a point which will yield only enough revenue to pay for the maintenance of the water front and to pay the interest on the investment in improvements. Where the wharves are privately owned, the maximum wharfage rates are sometimes prescribed by law or municipal ordinance in order to prevent extortion; but the lowest charges, considering the facilities furnished, seem to be found, as a rule, where the wharves are publicly owned. Thus at San Francisco the wharfage charges are unusually low, being only 5 cents per ton for grain and general merchandise, which at some other ports pay 25 cents and even 50 cents per ton. At Seattle a comparison of the charges at the munic-

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ipal and other wharves shows similar contrasts; thus the rate for lumber is 15 cents per M at the municipal wharf, as compared with 50 cents to $1 per M at other wharves.

The importance of wharfage charges is indicated by the statement of the traffic manager of the Pittsburg Chamber of Commerce, to the effect that excessive charges along the Ohio River offset the lower rates of water transportation as compared with rail transportation, and in the case of small towns cause the steamboats to pass by without landing at all, depriving these places of the benefit of water competition.

COMPULSORY PILOTAGE.

The employment of a pilot and payment of pilotage by vessels entering a seaport has commonly been made compulsory by state laws, in order to insure the presence of a sufficient number of skilled pilots to serve all vessels; but vessels engaged in the coasting trade only are now commonly exempted from the requirement of compulsory pilotage. In several of the South Atlantic States, however, sailing vessels in the coasting trade are still required to pay pilotage fees.

A large proportion of the sailing interests reporting to the Bureau of Corporations from the Atlantic coast complain of compulsory pilotage as an unjust discrimination against sailing vessels. Before entering the harbors and navigating the rivers of the several States south of Virginia on the Atlantic coast, sailing vessels are required by state laws to employ local pilots, or to pay the prescribed pilotage fee to the first pilot offering his services, whether he is actually employed or not. Formerly steamers were also subject to this requirement; but the difficulties of navigation which originally justified compulsory pilotage having been gradually removed by river and harbor improvements, steam vessels engaged in the coasting trade were freed from the requirement by act of Congress in 1871. Bills have repeatedly been introduced in Congress for the relief of sailing vessels from this burden, but they have failed of enactment.

Sailing interests maintain that sailing vessels can be as safely navigated on the waters of Southern harbors as can steam vessels.

Coasting vessels were exempted from compulsory pilotage in Virginia waters by the state legislature of 1908.

PART IV.—RAIL RATES AND WATER RATES, INCLUDING THEIR RECIPROCAL INFLUENCES.

GENERAL CONSIDERATIONS.

Water rates are usually more competitive than rail rates, mainly for the reason that water transportation requires practically no outlay for right of way and much less outlay for terminals than in the case of railroads. Operating costs of water lines therefore constitute a much larger proportion of the entire cost of transportation, and fixed charges are much lower.

Railroads have developed far more fully than water lines the system of freight classifications, there being at present three general

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rail freight classifications in the country, the Official, Western, and Southern. Some water lines operating jointly with rail lines have, however, adopted these classifications, or modifications of them. Traffic associations for the making of joint rates are much more common with railroads than with waterways. Unlike interstate rail rates, interstate water rates per se need not be filed or made public.

LONG-DISTANCE TRAFFIC.

The most striking characteristic of the American railroad rate system has been the extreme development of the long-distance traffic by means of relatively low rates. It is true that in many instances a tariff is used, somewhat approaching a "distance tariff," with rates proportioned roughly to the length of the haul, but the exceptions to the distance tariff principle are extremely common, and in fact the general tendency has been toward another principle, that of a wholesale rate. Railroads have given low rates for large long-distance traffic between important markets. There has been an extreme effort on their part to equalize different producing districts in the same market, regardless of differences in distance, and thus to make, to a certain extent, the producers of a given commodity all over the country competitors in all markets. This has resulted in a system of long-distance traffic and long haul peculiar to the United States.

This has had a marked effect on the waterway system. The business of the country has thus been adjusted to long-distance transportation, while our waterway system is mainly an aggregation of separate units of widely differing physical characteristics. It is therefore far less adapted for continuous through traffic that are the railroads. It is thus unable to meet the demands of modern business as developed by the railroad. In comparing, therefore, European water systems with our own waterways this difference must be borne in mind and we must recognize the peculiar demand which is made in this country upon our entire transportation system, including the waterways, and the peculiar difficulty which our waterways here have therefore to meet.

PRORATING.

The above considerations involve the question of the prorating between railroads and waterways. The railroads have exercised a marked effect over waterways by refusal to prorate with them in many cases, and especially with rivers and canals, although prorating is practically the rule among railroads. To give an example of prorating, a railroad, for instance, from New York to Chicago will join with a railroad from Chicago to San Francisco in making a through rate from coast to coast which is lower than would be the sum of the two local rates New York to Chicago and Chicago to San Francisco. This is called prorating. It is simply the making of the two roads one for the purposes of the agreement and applying to that joint route the well-known long-distance principle of a relatively lower charge for a longer distance. But in the case of rivers the railroads very rarely make any such lower through rates. The shipper in such cases sending his freight partly by rail and partly by water must pay the full rail rate to the water terminus,

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and then the full water rate to destination; that is to say, the sum of the two local rates. The railroad does not join with the waterway in making a through rate less than this sum and dividing this low rate between them. This, of course, tends to make the rates for an all-rail haul relatively lower than for the same distance by rail and water, because it applies to the all-rail haul the long-distance principle, while the rail-and-water rate covering the same entire distance is governed by the principle of short-distance shipments, which always take a higher rate per ton per mile.

Now, inasmuch as all shipments of importance for any considerable distance must go at least in part by rail, it is obvious that this power of the railroads to refuse to prorate with the water carrier is a very effective weapon in preventing shipments by water. Such failure to prorate is especially frequent and especially effective on the waterways of the Mississippi Valley. So far as present information goes, there are no such rail-and-water prorating arrangements in effect on the Mississippi below St. Louis, except at certain points on the Black River and to certain points in Louisiana not reached by rail. When prorating does appear as between rail and river lines, it is usually to points of minor importance or where without such rail-and-water arrangement the railroad could do no business at all.

It is true that in some cases the water lines have themselves preferred not to prorate with railroads, lest the water lines should by such "joint arrangement" make themselves subject to the special provisions of the interstate commerce act.

This power over prorating is also frequently used by the railroads in another way—that is to say, not to prevent shipments by water, but to send rail-and-water shipments over a certain favored water line, usually affiliated with or controlled by the railroad. It does this by exclusively prorating with that line.

That is to say, in brief, the railroads of the country, by refusal to prorate, can, and in large measure do, prevent the rivers and canals from becoming a part of the whole transportation system of the United States, or else they thus extend their control over the waterway system by prorating only with favored affiliated water lines. It follows, necessarily, that the water line thus favored will, other things being equal, overcome water lines not so favored.

COMPARISONS OF RAIL AND WATER RATES—ATLANTIC AND GULF COASTS.

Coastwise all-water rates on coal are much lower than rail rates as between coast points. To interior points, however, the railroads compete with the water routes. The same is true of lumber. Water rates on cotton between coast points are much below the rail rates. The all-water rate from Galveston to Boston in 1907 was 40 cents, while the all-rail rate was 97 cents. It should be noted, however, that local water routes along the coast and its tributary rivers do not show rates much lower than rail, thus differing from the long-distance movement.

CANAL RATES.

Any comparison here is extremely difficult by reason of the confusing variety of tolls, lockage and towage charges, and also the differ-

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ence in service. In general, canal rates show little advantage over rail rates. The inland route, however, between Philadelphia and Albemarle Sound by way of the Chesapeake and Delaware and other connecting canals has rates on coal and lumber considerably less than the all-rail rates.

GREAT LAKES.

In the through bulk movement of iron ore and coal between the upper lakes and Lake Erie, the advantage of the lake routes is so decisive that there is practically no rail competition. In the grain movement from Lake Michigan there has been active competition, and the rail rate varies accordingly, dropping in the summer during the season of navigation, and rising in the winter.

Water rates on lumber between lake points are lower than all-rail rates. The water rate Duluth to Chicago, 1907, was $2.50 per thousand feet; all-rail rate, about $4. But, again, as soon as interior points are considered, the advantage of the lake route declines. On through package freight the class rates by lake and rail and by canal and lake are regularly lower than the all-rail rates. From New York to Chicago the standard all-rail rate on class 1 is 75 cents; joint rail-and-lake rate, 62 cents; canal-and-lake rate, 42 cents. The differentials, however, are much less to interior points beyond the lake terminals.

MISSISSIPPI VALLEY.

The notable decline in traffic on the rivers of the Mississippi Valley, except that in lumber and coal, indicates clearly that the freight rates of the regular river lines, in connection with other expenses, offer little or no advantage to the shipper over railway rates. The coal traffic is perhaps the exception that proves the rule; and, as pointed out in a previous part of this discussion, it is of a unique character. The cost of transportation by river on coal from Pittsburg to Cincinnati is about 74 cents a ton, while the rail rate is $1.35; but this traffic is almost entirely confined to points along the river, because the railroads make such high local rates for river coal when shipped back from the river.

Similarly, logs and lumber are exceptional, because very little equipment is required to move them. An exact statement of the cost of raft transportation is impossible. One sawmill company estimates that it costs about 50 cents per thousand feet to float logs down the rivers in West Virginia, make up rafts, and tow the rafts to Cincinnati. The corresponding railroad rate is about $4.50 per thousand feet.

Class rates on freight moving between river points on the Ohio and Mississippi rivers and tributaries are usually less than the rail rates on the same traffic. Against these lower rates, however, must be considered the cost of marine insurance and terminal charges. The net result in most cases does not allow much differential in favor of the river. The river rates between St. Louis and Keokuk are about 20 per cent less than the all-rail rates. On cotton from river points below Memphis to that city the rail rate has been $1.25 per bale, river rate 75 cents, but to the river rate must be added 20 cents a bale for insurance and 25 cents for drayage in Memphis, and often the cost of a longer haul to the point of original shipment.

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PACIFIC COAST.

There is here a large coastwise movement of lumber with little rail competition. The rates fluctuate more or less. On traffic generally the influence of ocean competition is shown in the relatively lower rail rates between coast points than to inland points in the same territory. Rail rates from San Francisco to Ashland, Oreg. (an interior point), are twice to three times as much as are the rail rates to Portland, a much greater distance.

On local bay and river routes the railroads operate or control boat lines competing actively with independent boat lines. Rail rates to competitive points are thus in most cases reduced to the level of water rates, while to nonwater points at corresponding distances rail rates are much higher. These conditions appear on the rivers tributary to San Francisco Bay and on Columbia River and Puget Sound. Both rail and water rates along the Columbia River were reduced after the opening of the canal around the Cascades in 1895.

TRANSCONTINENTAL RATES.

The effect of water competition on transcontinental freight rates is quite marked. In general, class rates from New York to the Pacific coast via the Panama route are from 20 to 42 per cent lower than the all-rail rates. Rail rates to intermediate points slightly east of the Pacific coast are frequently determined by the rates to the coast plus the local rate back from the coast, these being among the marked exceptions to the principle of the long and short haul clause.

COMPETITIVE METHODS OF RAILROADS.

The power of granting or refusing prorating arrangements has already been noted as a most effective means of competition. Railroad control of strategic terminal facilities, and especially transfer points, is also an important factor.

Where water lines are weak, railroads have frequently engaged in destructive competition, making rates to competitive points along the waterway lower than rates covering similar distances inland. This has involved a number of interpretations of the so-called long and short haul clause of the interstate commerce act. This clause substantially prohibits the charging of "a greater compensation * * * for the transportation * * * under substantially similar circumstances and conditions for a shorter than for a longer distance over the same line in the same direction, the shorter being included within the longer distance." The words "substantially similar circumstances," however, have been so broadly construed as to take away largely the effect of the section. The United States Supreme Court, on a review of the decision of the Interstate Commerce Commission in the Alabama Midland case (168 U. S. 144; 1897), cited the possibility of potential water competition in connection with the competition of other railroads and trade centers, as a factor in establishing circumstances that were not "substantially similar," and to be lawfully considered in making railroad rates.

The result has been that the railroads have continued to reduce rates at many points where water competition occurs, while they may recoup themselves at inland points and thus, at no net loss to

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themselves, greatly injure the water-borne traffic. This is shown by a comparison of the railroad rates from points along the Mississippi to New Orleans with the rates from points inland at the same distance from New Orleans, the inland rates being in almost all cases much higher. Rail rates from New Orleans to Bayou Sara, on the river, average about 16 cents per hundred pounds less than to Hattiesburg, a shorter distance; to Greenville the rates average about 16 cents less than to Rolling Fork, Miss., a shorter distance; to Memphis the rates average about 17 cents lower than to Mount Vernon, which is less than half the distance.

Certain broad results of rail and water competition are illustrated in the following specific instances:

(*a*) That of the so-called Southeastern Differential Territory, a wide strip on the South Atlantic coast reaching inland several hundred miles. There is a strong waterway traffic from the North to the South Atlantic coast. Accordingly in this case the railroads have conceded this "differential territory," in a way, to the water lines. That is to say, there exists a general arrangement of long standing that the rates, for instance, from New York to Charleston by water, plus the rates by rail from Charleston inland, within the limits of this territory, shall be less than the all-rail rate from New York to the point of final destination. This differential in favor of the waterways, of course, tends to give them traffic within this territory.

This is evidently a case where there is strong water competition, and the railroads have been obliged to concede a share of the traffic to it. In this case also, however, the railroads have used another method, namely, that of absorbing the chief water lines. Most of the important coastwise lines running down the South Atlantic coast are controlled by or closely affiliated with important railway systems.

(*b*) The Great Lakes. This is another case of strong water competition. Here the railroads have used the latter method, namely, that of absorption or control, many of the important packet lines on the Lakes being owned or controlled by the trunk line railroads.

(*c*) The Pacific coast. Here the railroads have again used the latter method. Most of the important steamer lines, both ocean and local, are controlled by railroads.

(*d*) The Mississippi Valley. This is a case of a comparatively weak waterway, and its competition has been met by destructive competition on the part of the railroads, by the lowering of rates to competitive water points and the taking away of most of the former river traffic, so that it is now in a condition of extreme decline. The railroads have also in many cases succeeded in shutting in the Mississippi traffic—as, for instance, the coal business—practically to the banks of the river.

EFFECT OF WATERWAYS ON RAILROADS.

It is a curious fact that the ordinary inland waterway seems to be more potential in causing the reduction of railroad rates than in securing traffic for itself, though there is a marked difference between waterways in this respect, and any consideration of them must keep in mind these variations, and great care be taken in deducing general conclusions from the conditions of one class of water routes.

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Rates on cotton from interior shipping points show the influence of water competition in lower rail rates from river points such as Vicksburg and Augusta, as compared with nonriver points such as Jackson, Miss., and Atlanta. The rail rate from Charleston to Jacksonville is lower than from Savannah to Augusta, though the latter distance is only one-half the former. The lake rate Chicago to Sheboygan on class 1 is 27 cents and the rail rate 30, while to interior points at similar distances the rail rates are higher—to Fond du Lac 40 cents and to Oshkosh 43 cents.

Innumerable instances might be cited of the effect of water routes on rail rates. The foregoing are merely examples of a large class.

SCOPE OF THE EFFECTS OF WATERWAY COMPETITION.

It is an important fact that the effect of water competition on rail rates is much broader than would at first be expected, by reason of certain outside circumstances. These are the effect of competing markets, competing railroads, and the interdependence of railroad rates generally. An example may be stated as follows: Suppose that there is a rail rate from St. Louis to New Orleans on a given commodity of 40 cents a hundred pounds. Suppose also a similar rate exists on the same commodity from Chicago to New Orleans. Suppose, now, river competition between St. Louis and New Orleans arises suddenly and the St. Louis-New Orleans railroad is obliged to reduce its rate to New Orleans to 30 cents to meet this new river competition. Immediately the other railroad running between Chicago and New Orleans is met with a demand by its Chicago shippers that its rate also be reduced to 30 cents to New Orleans, in order to put Chicago producers of that commodity on a par with St. Louis producers in the New Orleans market. The Chicago-New Orleans road, therefore, having no interest in St. Louis, but being interested in the traffic from Chicago, is under strong inducement to make a similar reduction to 30 cents. Furthermore, if this be done, the other connections of the Chicago-New Orleans road will be affected by the change, as will also its immediate competitors from other markets competing with New Orleans. Finally, the numerous rate agreements, which often involve adjustments of rates over extensive areas, will also be affected by this change, so that the entire effect of the original river competition may thus be very greatly broadened.

CONCLUSIONS.

It will thus be seen that any consideration of the waterway question must first take account of its relations with the rail system. The two are inevitably part of a general transportation system. So long as the two are run in opposition the waterways will inevitably suffer by reason of their lack of adaptation to modern transportation demands. It is almost axiomatic that our waterways can not carry their reasonable proportion of the country's traffic, nor can their business ever be equal to their reasonable possibilities unless the present destructive competition with the rail system can in some way be modified and the two systems be made to cooperate.

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GROWTH OF INTERNAL AND FOREIGN COMMERCE.

By O. P. AUSTIN,
Chief of the Bureau of Statistics, Department of Commerce and Labor.

Conservation and commerce are so closely allied and the latter, commerce, so much affected by the application of the former, conservation, that a very few words on commerce may not be inappropriate to this discussion of conservation. This seems particularly true in case the discussion should relate especially to internal commerce, or the exchanges of our own people among themselves. True, the foreign commerce of the United States has grown from $300,000,000 in 1850 to $3,000,000,000 in the fiscal year 1908, being to-day practically ten times as much as in 1850; while population meantime was growing from 23,000,000 to 86,000,000, the per capita foreign commerce thus being $13.71 in 1850 and in the fiscal year 1908, $34.74, an increase of about 150 per cent in the per capita value of our foreign commerce. In internal commerce, however, which seems more closely related to the question of conservation, perhaps because of its greater importance than the foreign commerce and of its closer relation to the people in their every-day life—in internal commerce the growth has been much greater, the internal commerce of the United States having been valued at $2,000,000,000 in 1850 and over $28,000,000,000 in 1907, being thus practically fourteen times as much in 1907 as in 1850; while the per capita value of the internal commerce, which in 1850 was $86, was in 1907, $315. Thus, while foreign commerce is to-day ten times as much as in 1850, internal commerce is fourteen times as much as at that period; and the per capita of the foreign commerce is now practically three times as great as in 1850, while the per capita value of the internal commerce is now practically four times as much as in 1850. The internal commerce of the United States, including in this term merely a single transaction in all the merchandise forming the exchanges among our own people, was in 1850 practically seven times as great as the entire foreign commerce, and in 1907 was nine times as great as the entire foreign commerce, and equaled in value all of the imports plus all of the exports of every nation of the world.

The measurement of the internal commerce of the United States is arrived at by a process entirely different from that by which the foreign commerce is measured. In determining the value of the foreign commerce, we require from every importer and every exporter a statement of the true value of the merchandise which he is importing or exporting, and aggregating these imports of all ports and exports of all ports we get the grand total of our foreign trade, which in the fiscal year 1908 aggregated, as already indicated, $3,000,000,000,

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against a little more than $300,000,000 in 1850. To measure the internal commerce of the country is more difficult, however, since there are no gateways through which it passes and at which a statement of its value may be required. It is possible, however, by a different process to determine the value of the merchandise which passes from hand to hand for consumption within the United States; and as statements of foreign commerce include merely the value of the articles comprising it, the measurement of the internal commerce by a statement of the value of the articles which it includes, and thus of a single transaction in those articles, seems to be a logical and fair one, We may, therefore, assume that if we can determine the value of the articles which form the internal commerce the measurement may at least approximate in accuracy the measurement of the foreign commerce to which we are more accustomed.

Fortunately, we are able to determine at certain dates in our national history the value of at least the principal articles entering the internal commerce of the country. The census shows the value of manufactures, of agricultural products, the products of the mines, the fisheries; and the record of imports shows the value of merchandise brought in from foreign countries and subsequently entering the internal commerce. By aggregating these stated values at the place of production of the principal articles entering the internal commerce of the country and adding a reasonable sum as the probable cost of transporting them to the consumer, we may at least approximate the value of the merchandise consumed among our own people, a single transaction in which may be properly accepted as a measurement of the value of the internal commerce. The census of 1900 showed the value of manufactures in the United States to be $13,000,000,000; of products of agriculture, practically $4,000,000,000; and of minerals, about $1,000,000,000. The importations of 1900 were practically $1,000,000,000 in value. Adding to these the products of the forests and fisheries and the increased value of all products due to transportation from the place of production to the purchaser, we may fairly set down the value of the internal commerce of the country as measured by a single transaction in those articles at $20,000,000,000 in the year 1900.

Applying this method to earlier and more recent years, I find that the value of the internal commerce of the country may be reasonably estimated at $2,000,000,000 in 1850, $3,500,000,000 in 1860, $5,000,000,000 in 1870 (gold value), $7,750,000,000 in 1880, $12,000,000,000 in 1890, $20,000,000,000 in 1900, and $28,000,000,000 in 1907, the last named year being estimated upon the census figures of manufactures for 1905, the Agricultural Department's estimate of the value of farm products in 1907, the Geological Survey estimate of the value of mineral products, and the stated value of imports of that year. Comparing these with the census figures of population, we get the per capita value of the internal commerce in 1850, $86; in 1860, $111; in 1870, $132; in 1880, $154; in 1890, $192; in 1900, $261; and in 1907, $326. Meantime the per capita wealth has grown, according to the census figures, from $307 in 1850 to $514 in 1860; $780 in 1870; $850 in 1880; $1,039 in 1890; $1,165 in 1900; and $1,310 in 1904, the latest year for which estimates have been made, the increase in per capita wealth having been slightly greater than the increase in per capita of internal commerce.

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IRRIGATION.

By F. H. NEWELL,
Director United States Reclamation Service.

The National Government has passed three important laws for the encouragement of irrigation; (*a*) The desert land law, which was best adapted to individual enterprise in the development of comparatively small tracts of land by irrigation systems of moderate size; (*b*) The Carey act, which was designed to encourage corporate irrigation of public land under state auspices; (*c*) the reclamation act, which provides for construction of irrigation works by the National Government itself. Enumeration was made by the United States census of the acreage irrigated in 1889, 1899, and 1902. With those figures as a guide, and by the use of the general information possessed by the Reclamation Service, an estimate has been made of the acreage irrigated in 1907. The results given in the following table include very large areas which receive only one or two irrigations by flood water, and others where the supply is inadequate.

Irrigation in the United States.

NUMBER OF FARMS IRRIGATED.

Year.	United States.	Arid region.	Semiarid region.	Rice region.
1907	[a] 167,200	152,000	7,800	7,400
1902	133,356	122,156	7,021	4,179
1899	110,117	102,819	4,897	2,401
1889	54,136	52,584	1,552	.....

[a] Estimated.

NUMBER OF ACRES IRRIGATED.

1907	[a] 11,000,000	9,700,000	425,000	876,000
1902	9,681,289	8,471,641	405,449	600,199
1899	7,778,904	7,963,273	266,417	251,214
1889	3,631,381	3,564,416	66,965	.....

[a] Estimated.

Irrigation by individual effort has been undertaken in each instance in a small way, but in the aggregate this method has led to the most important development and has resulted in the largest total acreage. It is also being developed to some extent by corporate enterprise, but results from this source are relatively meager, except where the corporations are of a community character. Cooperative communities have done much in the past and their future works will probably be important. Development by States under the provisions of the "Carey Act" promises well in some localities where there is efficient state supervision, as in Idaho, Wyoming, and Oregon; large results have already been accomplished in the first-named State. National

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development through the agency of the Reclamation Act is beginning to show results and is steadily proceeding. It has been confined mainly to those enterprises which are too large, too costly, or too slow in producing returns to tempt private or corporate investments.

The Reclamation Service has 29 projects in various stages of construction; these contemplate the ultimate irrigation of 2,700,000 acres, against a total acreage of 367,023 for which water was furnished in 1908. The following table shows the distribution of the projects, the total ultimate irrigable area under each, and the irrigated areas for 1908 and 1909:

Irrigation projects.

State.	Project.	Irrigable area.	Irrigated 1908.
		Acres.	*Acres.*
Arizona	Salt River	272,000	115,000
California	Orland	14,000	.....
California-Arizona	Yuma	92,000	3,800
Colorado	Grand Valley	62,000	.....
	Uncompahgre	147,000	15,600
Idaho	Minidoka	74,000	24,464
	Payette-Boise	315,000	55,000
Kansas	Garden City	8,500	5,558
Montana	Huntley	28,000	4,400
	St. Mary	.....	.....
	Sun River	256,000	.....
Nebraska-Wyoming	North Platte	164,000	23,220
Nevada	Truckee-Carson	200,000	27,450
New Mexico	Carlsbad	20,000	8,000
	Hondo	10,000	1,500
	Rio Grande	180,000	17,000
North Dakota	Buford-Trenton	12,500	1,200
	Williston	12,000	2,000
North Dakota-Montana	Yellowstone	66,000	.....
Oklahoma	Cimarron	.....	.....
Oregon	Umatilla	20,000	2,500
Oregon-California	Klamath	187,000	9,378
South Dakota	Belle Fourche	100,000	5,000
Utah	Strawberry	60,000	.....
Washington	Okanogan	10,000	1,353
	Sunnyside	90,000	42,000
	Tieton	30,000	.....
	Wapato	120,000	.....
Wyoming	Shoshone	150,000	2,600
		2,700,000	367,023

Under the Carey Act there have been approved 1,716,424 acres for construction, and patents have been granted covering 293,083 acres.

The following table shows the location of the lands being irrigated under this act:

Segregations applied for under the act of August 18, 1894 (28 Stat. L., 372–422), and the acts amendatory thereof, with the action taken thereon, from the passage of the act to July 1, 1908.

[Areas in acres.]

State.	Selected.	Rejected, relinquished, etc.	Approved, not patented.	Approved and patented.
Colorado	59,807.94	5,704.95	54,102.99	.....
Idaho	1,180,566.17	265,828.94	662,254.00	156,954.90
Montana	104,587.98	2,792.53	83,498.54	18,296.91
Nevada	12,644.61	8,000.00	.....	.....
Oregon	432,202.53	78,507.31	245,287.52	50,063.13
Utah	328,327.40	236,980.83	48,226.74	.....
Washington	155,649.39	155,649.39	.....	.....
Wyoming	965,598.64	198,994.18	623,054.44	67,768.72
Total	3,239,384.66	952,458.13	1,716,424.23	293,083.66

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Oregon segregation list No. 5, covering 58,344.57 acres, is now pending before the Secretary on appeal from the decision of the General Land Office rejecting it.

Wyoming segregation list No. 27, covering 26,936.03 acres, was rejected by the General Land Office, which decision was affirmed by the department, but said decision has not yet become final.

Irrigation under the Indian Service is rapidly increasing.

The extent to which the irrigated area in the arid and semiarid regions can be increased can not be accurately estimated with present knowledge. If all the run-off waters of the arid region could be conserved and employed in irrigation, the total area might, perhaps, be brought to nearly 60,000,000 acres. This is very uncertain, however, as our knowledge of run-off is confined to only a portion of the streams, and is incomplete; furthermore, such an estimate involves assumptions regarding the duty of water that may introduce large errors.

It is known, however, that large portions of the water of the arid region can not be used in irrigation, as no irrigable land exists upon which it can be brought at feasible cost. In general, it may be stated that the value of irrigated land is increasing, and certain developments are tending to decrease costs of construction, so that it is impossible to draw any approximate line of demarkation, even if we had full knowledge regarding present costs. This would require elaborate surveys, which have not been made. For these reasons any present estimate of the total irrigable area would necessarily be little better than a guess. With present data, the closest statement is probably between 40,000,000 and 50,000,000 acres, including that now under ditch.

The subjects of irrigation, forestry, navigation, power, domestic water supply, and drainage are all closely interrelated and should be thoroughly studied together, not only in the arid but in the humid regions. No one of these questions can be properly treated without full regard to all the others. Proper study of these comprehensive questions should include more extended observations of rainfall and evaporation, especially in high altitudes, and of the annual flow of all streams. Comprehensive topographic maps should be made showing the areas of drainage basins, the location of reservoir sites, and their relation in altitude and location to irrigable lands and to power and navigation resources. Such maps are the basic information most urgently needed for all land classification, and without them no wise policy can be adopted.

Water laws.

Both state and national laws are incomplete in permitting and encouraging the settlement and improvement of lands which should be reserved for reservoir sites. Thorough surveys should be made and all feasible reservoir sites discovered and reserved for development.

The present laws in some States tend to promote irrigation, but in others they do not. The most primitive form of regulation of the use of water in irrigation is best exemplified by the present laws of the State of California. These declare the principles of priority and beneficial use, and provide that claims to the use of water shall be recorded in the form of a notice of appropriation, and shall be perfected by application to a beneficial use. At the same time they try

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to recognize as concurrent on the same stream rights derived by prior appropriation and rights depending on riparian ownership. The riparian doctrine of water rights should be definitely and permanently abrogated in all arid regions. This has been done in some States by constitutional provision and in some by judicial decision. In all the States of the arid region where the riparian doctrine is recognized, material modifications in the old common-law doctrine have been made and put into effect.

The form and theory of these laws have been developed by several of the States, elaborating upon the principles of the California laws and the methods established in that State.

The operation of the earlier forms of these laws places no restraint upon appropriations of water. The courts in passing upon the claims of the appropriators, having scant information concerning the amount of water available for use, with no guide to the quantities which should be applied in the cultivation of crops, and confronted with the excessive claims of the parties, have often adjudicated rights to the use of water many times in excess of the amount carried by the stream.

The knowledge obtained during recent years concerning the discharge of streams and the use of water has caused such decrees to become exceptional in present practice. Nevertheless, the need for a more careful regulation of the appropriation and use of water has been apparent for many years.

In 1890 the State of Wyoming enacted a code of water laws providing for supervision of the utilization of the water supply through a state engineer and state board of control who adjudicate rights to the use of water in the first instance. The division superintendents and water masters have immediate charge of the distribution of the water in the various water divisions.

Nebraska subsequently adopted a code of water laws similar to the laws of Wyoming.

Idaho, Utah, and Nevada in 1903 adopted codes of water laws based upon those of Wyoming with, however, a number of important modifications dictated by experience and the development of irrigation practice.

At the sessions of the legislatures of Oregon and Washington in 1903, the governors were directed to appoint commissions to prepare and submit drafts of a code of irrigation law.

At a joint session of the two commissions with the then chief engineer and other members of the Reclamation Service held in August, 1904, the fundamental principles of a modern irrigation code were discussed. There was also some consideration of the provisions which should be incorporated in such a code to facilitate the operations of the Federal Government in carrying on the work of constructing the irrigation systems contemplated by the act of Congress approved June 17, 1902 (32 Stat., 388), known as the Reclamation Act.

After this meeting, a state code of water laws was drafted by Mr. Morris Bien, supervising engineer of the United States Reclamation Service, which, in 1905, was adopted without material change by the legislatures of North Dakota, South Dakota, and Oklahoma. The legislatures of Oregon, Washington, and New Mexico adopted parts of this code, but omitted some of the most important features. This

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code does not involve any new principles, but constitutes a revision and combination of the features of the more modern statutes, arranged as a consistent and complete code.

Proposed water code.

A state code of water laws should provide for the appropriation, adjudication, and apportionment of the waters of the State, and divides itself naturally into four branches.

First. A declaration of the fundamental principles upon which the right to use water shall be based.

Second. The adjudication of rights to the use of water claimed under the previous laws, thus determining the unappropriated public waters.

Third. The regulation, control, and determination of the rights to water to be subsequently acquired.

Fourth. The regulation and control of the distribution of water, rights to the use of which have been established.

The code under discussion is arranged to provide appropriate procedure for the application of these principles.

Under the first heading the fundamental principles are few and well established, namely, that all the waters within the limits of the State belong to the public and are subject to appropriation for beneficial use, except from sources of supply which are navigable; that the prior appropriation of water shall be the basis, and beneficial use the measure and the limit of the right; that the use of water is a public use, and private parties may exercise the right of eminent domain for the utilization thereof; and that water used for irrigation shall be appurtenant to the land on which it is used.

Under the second heading, providing for the adjudication of rights claimed under prior laws, it is now generally conceded that the final adjudication must be by the courts. The codes of the different States contemplate various forms of procedure. In the code referred to, a state engineer, appointed for six years by the governor subject to confirmation by the Senate, is to make a complete hydrographic survey of a stream system, obtaining all the data necessary to determine the amount of water available and the rights of the parties entitled to the use of it. This material is turned over to the attorney-general of the State, who is required to enter suit promptly for the determination of the rights of all parties and to prosecute the same diligently to a conclusion. In all suits for the determination of the right to the use of the waters of any stream system, all who claim the right to use such waters shall be made parties. In all suits involving the determination of water rights, the attorney-general is required to intervene on behalf of the State, if in the opinion of the state engineer the public interest requires it.

The third subject, namely, that of the regulation, control, and determination of rights to the use of water to be acquired, is placed in the hands of the state engineer. The procedure proposed is substantially the same as that adopted in the other States having a modern irrigation code with some differences of detail.

The principal feature to be noticed is that before any work looking to the construction of an irrigable system is commenced, and after the state engineer has passed upon the form and substance of the ap-

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plication, the intention to appropriate the water shall be published in a newspaper circulated in the community. After such publication the state engineer will approve the application if no valid objection is presented.

When the construction is completed, the works are to be inspected and approved by the state engineer, who will then determine their capacity, which will limit the amount of the appropriation. Afterwards when the water is applied to a beneficial use, the state engineer makes a further inspection, whereupon he issues a license for the appropriation of the amount of water which has been applied to a beneficial use. A time limit is fixed for completion of construction and for beneficial use.

For the distribution of the water, which comes under the fourth branch, the States are divided by the law into water divisions by drainage areas, each under the supervision of a water commissioner appointed by the supreme court of the State. Their function being the distribution of water under judicial decree or appropriation, they may be regarded as, in a sense, officers of the court. The water commissioners with the state engineer constitute a board of water commissioners, of which the latter is president. The water commissioners each serve six years, their terms being so arranged that a new one is appointed every two years. This board has general supervision over the waters of the State.

The actual work of distributing the waters to those entitled to use them is performed by water masters appointed by the water commissioners with the approval of the state engineer. Each water master has charge of a water district set apart by the state engineer, as found necessary from time to time. The operations of the water master are under the supervision of the water commissioner, and their acts are subject to appeal to the state engineer.

The cost of the water distribution is borne by the water users. The general expenses of the state engineer and the water commissioners are paid by the State. The greater part, if not all, of this expense will be returned to the state treasury by the fees collected by the state engineer and by the repayment of the cost of hydrographic surveys by the parties to the suits for adjudication.

Special reference should also be made to the features of the draft relating to the work under the federal Reclamation Act.

In order that the State may obtain the full benefit of this work and to prevent serious interference with, and perhaps the entire abandonment of, the projects which are considered for investigation, it is provided that the water supply for such projects shall be reserved from general appropriation until the investigations of the Reclamation Service shall determine the precise amount required for the project, the remainder being then released from such reservation.

It is also provided that state lands coming under such project shall be disposed of in harmony with the plans for the disposition of the lands of the United States, and that lands required for the reclamation project for irrigation works shall be transferred to the United States without charge.

In all sales of state lands after the enactment of the code, the conveyance is to reserve right of way for ditches or canals constructed by authority of the United States.

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The theory of these provisions is that the State regulates the appropriation of the water, exercising this power and holding the land in trust for the public, and when the interests of the public are so directly involved as in these large irrigation projects, and when, further, there is no element of individual speculation or profit in the construction of the works, which are for the purpose of establishing the maximum number of homes on the land, it is the duty of every State to which the Reclamation Act is applicable to assist with every resource under its control.

It will be of interest to review several of the other provisions of the draft.

Units of measurement are established; the cubic foot per second for the flow of water and the acre-foot for volume. The miner's inch is fixed as one-fiftieth of a cubic foot per second, unless a different ratio has been agreed upon by contract or established by actual measurement or use. The miner's inch has been used in some States as a unit, but it is unsatisfactory, because it is not easily defined with exactness.

The amount of water which may be appropriated for irrigation is limited to 1 cubic foot per second for 70 acres or its equivalent.

While it is conceded that water used for irrigation must be appurtenant to the land, the fact should be recognized that conditions may arise to make it impracticable or uneconomical to continue to irrigate a particular tract. Provision is made so that the use of water may be severed from the land after application to the state engineer, due publication of notice of such intention, and approval by the state engineer. Similar provision is made for a change in the nature of the use to which the water is applied, or in the place of diversion, storage, or use.

The subject of seepage water is one that has given much trouble, and provision is made for the appropriation thereof in the same manner as other waters, with the requirement that the appropriator must pay reasonable charges for storage or carriage to the owners of the irrigation works from which it comes, provided that the seepage can be traced to such works beyond reasonable doubt.

All decisions of the state engineer or water commissioners affecting a substantial right are subject to appeal to the courts.

Adoption of code.

In the session of 1907 the Montana legislature considered a draft of a code prepared by a commission appointed by the governor which followed substantially the code referred to, but it was not adopted. The same is true with the legislature of Oregon.

During the year 1908 there has been a general movement toward the preparation of a code substantially in the form considered in the State of Oregon, and it is probable that it will be strongly urged upon the legislature early next year.

In many of the States statutes have been adopted tending toward the system discussed, and as this procedure is gradually enforced and modified as may be found advisable after experience, those States in which such laws have been enacted will do much toward the proper promotion of the irrigation industry.

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It is generally conceded that those States in which statutes of this kind are not in force can best assist in the development of irrigation by following the principles and procedure there indicated.

One important feature of the law of irrigation has thus far received no attention in legislation, namely, the regulation of interstate waters. The decision of the United States Supreme Court in the Kansas-Colorado case (206 U. S., 46) and the decisions of some of the district courts of the United States in other cases, together with some decisions by state courts, have shown a tendency to consider this question, but in no case has there been an announcement of a principle which tends to meet the complicated conditions.

All the cases concerning interstate waters have involved only specific rights of the litigants; nothing has yet been accomplished outlining the method of providing for an adjudication of the waters of an interstate stream in such manner as to determine all the rights involved.

The principal difficulties arise from the fact that suit may be brought by one party against another and a decision obtained, which would not, however, bind anyone who is not party to the suit, and the complications in judicial procedure are such as to make it difficult, if not impracticable, under present conditions and rulings to bring into consideration in any one case all rights on interstate streams in two or more States and so arrange that one adjudication shall determine the rights of each party as against all other users of water from that stream.

Whether this matter can be adjusted by the courts themselves without the assistanc of legislation or whether legislation is absolutely necessary has not yet been demonstrated.

It has been proposed by some that Congress should provide for a tribunal empowered to investigate claims to the use of water of interstate streams and to prepare reports upon all facts affecting priorities and the use of water, the same to be submitted to the federal courts for adjudication, following in general the procedure outlined in the proposed code in regard to the adjustment of water rights within the State.

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IRRIGATION.

By Dr. SAMUEL FORTIER,
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LAND NOW UNDER IRRIGATION IN THE UNITED STATES.

The following table gives estimates of the areas now irrigated in the arid States and Territories. For the States which have state engineers charged with the supervision of their water supplies, except Montana and Nevada, the estimates are made by the state engineers. Since these men are charged with the distribution of the waters of their respective States to the lands irrigated, their estimates are probably the best obtainable and very near the truth. For Arizona, Texas, Washington, and Nevada the estimates are made by men connected with the territorial and state agricultural colleges, whose duties have made them especially well-informed along this line. For California, Kansas, and Montana the estimates are made by representatives of the irrigation investigations of the United States Department of Agriculture, who have made studies of irrigation in those States, and can be considered the best authorities on conditions in them. The areas devoted to rice in Arkansas, Louisiana, and Texas are included in this table for convenience:

Areas irrigated in the United States.

State.	Area irrigated.	Authority.
	Acres.	
Arizona	200,000	R. H. Forbes, director Arizona Agricultural Experiment Station.
Arkansas (rice)	6,000	Yearbook, U. S. Department of Agriculture, 1907.
California	1,800,000	F. W. Roeding, U. S. Department of Agriculture.
Colorado	1,852,900	T. W. Jaycox, state engineer.
Idaho	2,665,000	Jas. Stephenson, state engineer.
Kansas	51,500	D. H. Bark, U. S. Department of Agriculture.
Louisiana (rice)	310,000	Yearbook, U. S. Department of Agriculture, 1907.
Montana	1,500,000	Samuel Fortier, U. S. Department of Agriculture.
Nebraska	250,000	
Nevada	500,000	G. H. True, University of Nevada.
New Mexico	400,000	V. L. Sullivan, territorial engineer.
North Dakota	[a] 64,300	T. R. Atkinson, state engineer.
Oregon	500,000	J. H. Lewis, state engineer.
South Dakota	42,000	S. H. Lea, state engineer.
Texas:		
General	500,000	J. C. Nagle, Texas Agricultural College.
Rice	284,000	Yearbook, U. S. Department of Agriculture, 1907.
Utah	850,000	W. W. McLaughlin, U. S. Department of Agriculture.
Washington	260,000	O. L. Waller, State College of Washington.
Wyoming	1,000,000	C. T. Johnston, state engineer.
	13,035,700	

[a] Includes total under Reclamation Service ditches, 44,800 acres, much of which is not yet irrigated.

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In addition to the areas given in the table there is a constantly increasing area being irrigated in the humid States. This is especially true of the trucking districts of the South Atlantic and Gulf States. However, no reliable estimates of these areas can be made. Census Bulletin 16 gives the area in 1902 as 5,788 acres, which is an increase of 76 per cent over the area reported in 1899. Assuming a like rate of increase since that time would make the present area about 14,000 acres.

HOW MUCH MORE LAND CAN BE IRRIGATED.

Prior to 1890 erroneous ideas prevailed regarding the extent of land which could be irrigated in the arid region. So little was then known of the water resources of this region and so large seemed the irrigable lands that the most conservative estimates were much too large. Fifteen or more years ago the most generally accepted estimate was 100,000,000 acres. As data on the flow of western streams were accumulated by the United States Geological Survey and as more irrigation enterprises were carried out, men began to have a more accurate conception of the limitations of the water supply and the difficulties to be overcome in utilizing even a small portion of certain streams. From 100,000,000 acres the estimate shrunk to 90,000,000 and then to 75,000,000. For a number of years it halted at 65,000,000 acres, but from reports received from the best authority in each of the sixteen arid States and Territories during the months of September and October, 1908, the total extent of land possible of irrigation is below 45,000,000 acres. It is reasonable to conclude that this estimate is likewise too large.

Areas irrigable in arid region of the United States.

State.	Area irrigable.	Authority.
	Acres.	
Arizona	1,000,000	R. H. Forbes, Director Arizona Agricultural Experiment Station.
California	10,000,000	F. W. Roeding, U. S. Department of Agriculture.
Colorado	2,893,900	T. W. Jaycox, state engineer.
Idaho	5,446,000	James Stephenson, state engineer.
Kansas	103,500	D. H. Bark, U. S. Department of Agriculture.
Montana	6,000,000	Samuel Fortier, U. S. Department of Agriculture.
Nebraska	1,000,000	
Nevada	1,500,000	G. H. True, University of Nevada.
New Mexico	2,000,000	V. L. Sullivan, territorial engineer.
North Dakota	1,540,000	T. R. Atkinson, state engineer.
Oregon	3,000,000	J. H. Lewis, state engineer.
South Dakota	191,900	S. H. Lea, state engineer.
Texas:		
General	500,000	J. C. Nagle, Texas Agricultural College.
Utah	2,000,000	
Washington	1,000,000	O. L. Waller, State College of Washington.
Wyoming	6,200,000	C. T. Johnston, state engineer.
Total	44,375,300	

The spirit of the West is characterized by its hopefulness, and state engineers and others are more or less influenced by this. Besides, state officers desire, as a rule, to make a good showing for their respective commonwealths, and the tendency is to exaggerate rather than to minimize the extent of the natural resources. This is particularly true of those pertaining to land and water.

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Such men are apt to base their conclusions on the total available supply. Quite frequently they fail to consider whether it would pay to utilize all this supply. There are limited portions of the arid region so favored by climatic and soil conditions that crops to the value of several hundred dollars per acre can be annually grown. In such localities a large amount of money may be profitably expended in providing a water supply by means of deep wells or storage reservoirs. In the vicinity of Riverside, Cal., the annual cost of water to irrigate citrus orchards exceeds on an average $22 per acre. This price includes the annual charge for maintenance and operation as well as the interest on the value of a water right. When the cost is so high, the water may be pumped to considerable heights, and storage reservoirs may be built whose first cost exceeds $100 per acre-foot. Wherever such costly undertakings are successful, practically all of the so-called available water supply can be utilized.

On the other hand, in the colder portions of the arid region, where the crops grown are confined chiefly to grains and grasses, water for irrigation has a low value, and the time will never come when any agency, individual, corporate, or governmental, can afford to build irrigation structures of such magnitude and cost as will serve to utilize all of the available water. Since this limitation, arising from the amount of money which can profitably be expended on any project, calls for the most careful consideration in perhaps 95 per cent of the entire region west of the Missouri River, it follows that the value of water in irrigation is a controlling factor in determining the extent of land which can be irrigated.

A large part of the total available water supply of the arid and semiarid regions of the United States is already used each crop-growing season. In taking water from natural streams and other sources of supply, conducting it frequently long distances, and applying it to arid lands much is wasted. When all losses are deducted, the quantity of water which subserves a useful purpose in the growth of plants is small in comparison to the quantity diverted. Those best informed quite generally believe that two-thirds of the water which is now diverted subserves no beneficial purpose in nourishing plant life. In the prevention of at least a part of this waste is to be found one of the best means of conserving the water supply of the arid region.

According to the census of 1900, the area irrigated in the United States in 1899 was 7,539,545 acres, while the special irrigation census of 1902 gave 9,487,077 acres. Assuming the same rate of increase the area irrigated in 1908 would be over 14,000,000 acres. This estimate, although doubtless too large, is confirmed in a way by recent reports from western state and territorial engineers. These aggregate for the sixteen Western States and Territories over 13,000,000 acres. Now, when one considers the quantity and value of the water which is annually applied to so large an extent of land and the high percentage which might readily be saved by a more economical use, the figures are startling. A saving of even 10 per cent of the quantity now used and making it available for other lands would provide a supply for 1,400,000 acres, representing a value of about $50,000,000. A consideration of the extent of the losses herein briefly outlined would seem to indicate that fully 33⅓ per cent of the present supply might be saved by the prevention of a part of the waste. The water

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thus saved would provide a supply for an additional acreage of four and one-third million acres, and represent a value of over $150,000,000.

Seepage and evaporation losses from canals by groups.

[In cubic feet per second.]

Number of canals tested.	Capacity.	Miles of canal tested.	Total discharge.	Total loss.	Percentage of loss per mile.
17	100 cubic feet per second or over	359.63	5,319.51	1,037.84	0.92
20	50 to 100 cubic feet per second	270.97	1,458.65	341.36	1.73
20	25 to 50 cubic feet per second	114.68	714.21	142.92	3.50
26	Less than 25 cubic feet per second	108.63	387.04	102.69	6.20

A commonly accepted estimate of the loss from ordinary unlined canals in earth is 25 per cent of the amount of water passing through the head gate, and from the results of measurements given this estimate seems to be conservative. The additional loss in the laterals and field ditch is usually as much more, so that as a rule, for every gallon of water that is taken from a stream only one-half reaches the fields to be irrigated. The portion which percolates through porous material is not always wasted. The seepage from one canal may be obtained by another at a lower elevation. On the other hand, seepage waters frequently do no end of damage to low-lying lands and the benefit gained by a second diversion and use is more than offset by the damage done in water-logging soils.

LOSSES ARISING FROM IMPERFECT WATER-RIGHT CONTRACTS.

In the large majority of canal contracts, the canal company agrees to supply a stream of a given size continuously or in rotation for the irrigation of a definite tract of land. In the event of a shortage of water each water-right holder receives only his pro rata share of the water available. Since each water user is expressly forbidden by the terms of the contract to use the water thus purchased on any land other than that specified, there is no inducement for him to economize by using less than the amount stated in the contract.

This form of contract was popular at a time when water was cheap and abundant, and in consequence the water allotted to each acre is usually far in excess of the actual requirements of the crops when the subsoil becomes partially filled with waste water.

In some of the more recently organized irrigation companies the water is measured out to each user and he pays only for what he gets. Such contracts place no limitations on the place of use. In the most common form of contract the self-interest of the irrigator leads him to waste water by applying too much; in the later form his interests are best served by the strictest economy. If in future all companies organized for this object could be induced to sell water by measurement, requiring the user to pay a quantity rather than an acreage rate, much water could be saved. Most farmers who now use and waste every summer sufficient water to cover their fields to a depth of 4 feet under the old system would find that they could produce more valuable crops with the use of 2 feet under the form of contract herein recommended.

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LOSSES DUE TO UNJUST AND IRREGULAR DISTRIBUTION.

The large majority of rights to the use of water has never been determined by a competent tribunal. In consequence, disputes among neighbors over the quantities each is entitled to are common. Such uncertainty leads to overreaching and injustice. When one man takes twice as much water as properly belongs to him his neighbor may have none. To insure a supply it is usually necessary for one man to stand guard over the headgate while his comrade tends to the irrigation of the field. Under such conditions it is impossible to use water to the best advantage and in the most economical way.

LOSSES FROM POORLY PREPARED FIELDS.

The surface of the fields is rarely prepared with that skill and care which rapid and effective watering demands. A thorough grading and smoothing of the surface is necessary before water can be evenly distributed over the surface. Failure to prepare the surface properly, results most frequently from carelessness, because money and labor thus spent bring in large returns. In addition to the amount of water saved, the labor of irrigating the properly prepared field is lessened, the soil is not damaged by an overdose of water in the low places, there is considerable increase in the yield, and the quality of the crop is improved.

LOSSES IN THE APPLICATION OF WATER.

These losses are due to carelessness and unskillful use, evaporation from the wet soil, and percolation beyond the reach of the roots of plants. All of these losses are increased when the surface is not properly graded, but even in well-graded fields it is possible to lose a large part of the water which is delivered at the highest point by unskillful use. The application of frequent light irrigations on the surface tends to keep the surface moist the greater part of the time, and in consequence much of the moisture is evaporated. In the best methods of applying the water the losses due to evaporation will be considerable unless frequent cultivation is resorted to. Deep percolation is another source of loss. When the subsoil is porous it is difficult to prevent, even under the best practice, considerable quantities from percolating to depths far beyond the deepest roots. On the other hand, in stiff retentive soils there is not sufficient percolation, and under careless use a large part is allowed to flow off the surface and pass beyond the tract to be watered.

THE RELATION OF IRRIGATION TO FORESTS.

In Bulletin No. 38 of the Utah Agricultural Experiment Station, the beneficial effects of forests in increasing the water supply is set forth in the following words:

> The municipal engineer increases the size of sewers which drain areas covered with an impervious lining, such as the roofs of buildings, paved streets, and cemented sidewalks. He well knows that if a heavy rain falls on such a district, the greater part will immediately run off and the sewer must be made large enough to carry this flow. The same amount of rain may fall on lawns, vacant lots, or porous streets without producing more than 40 or 50 per cent of the maximum discharge.

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In like manner, when rain falls on a mountain slope that has been denuded of its natural forest growth, there is little, if any, vegetable mold to absorb and retain, for a while, the moisture. The rain drops fall on the rocky surface, gather into rills, and these into streams, until a mountain torrent is formed. These intermittent streams that flow with great rapidity are in nearly every sense detrimental to the irrigator.

On well-wooded mountain slopes the case is different. Here the leaf mold of centuries absorbs and holds back the rainfall, and weeks or even months afterwards some field or orchard far down in the valley may be invigorated by its presence. Here, too, the winter snow finds a resting place, sheltered alike from wind and sunshine. The heat of spring melts the snow gradually and permits a large part to sink into the vegetable mold, from which it is gradually conveyed beneath the surface to do good service to the irrigators of the plains.

In the foregoing brief paragraphs are set forth the chief benefits of forests in equalizing the streams. It is not true, as some contend, that forests increase the water supply. The vegetable matter which covers forests not only retains a large part of the natural precipitation but also no small portion of the melting snows in seasons of the year when water is abundant and possesses little or no value. The water which is thus held back in these natural storage reservoirs usually seeps, in course of time, down the mountain slopes and forms the chief source of late summer and autumn stream flow. Vegetable mold also prevents the loss of water by evaporation from the surface. Many experiments have been made to determine the effect of such mulches in preventing evaporation, and almost without exception all go to show the beneficial effects of such a mulch.

The part which forests play in equalizing the water supply, holding back a portion of the spring floods and delivering the greater part of the water thus stored later on in the season to feed the springs at a lower elevation, is well understood and has been fully presented of late in a large number of publications relating to forestry and irrigation.

There are, however, other phases of the subject which should not in fairness be overlooked. One of these is the effect of deep, compact snowdrifts which lodge in ravines and melt slowly during the summer months. There is no question that most of the water supply which is derived from this source is usually accredited to the beneficial effects of forest growth. Any one who is familiar with the main ranges of the Rocky Mountain region has noticed large accumulations of compact snow in the deep ravines of the mountains during the summer and autumn months when all the snow has disappeared from the forests. Men who have closely observed the effects of these snowdrifts are led to believe they conserve more water than the forests.

There is another phase of this subject which deserves a passing word. That is the large amount of water required to nourish forest trees. It is well known that every plant, whether it be a stalk of grain or an orchard tree, requires a large amount of water to maintain a healthy growth. The same is true of forest trees, with this difference, that as their transpiration surface is much greater, much more water is required. When this water is withdrawn from the soil in seasons of scarcity it must tend to greatly reduce the quantity of water which reaches the streams in the immediate neighborhood.

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THE RELATION OF IRRIGATION TO FLOODS.

The quantity of water diverted from streams in flood time for the irrigation of land is usually so small in comparison to the stream itself as to produce little or no effect in lessening the flow or in preventing destructive action by floods. While this has been generally recognized, the building of storage reservoirs for such purposes has been quite generally and persistently advocated for a number of years. Many prominent men outside of the engineering profession and quite a number of hydraulic engineers have advocated this means of controlling flood waters. They claim that if the water of streams and their tributaries which are subject to destructive floods were diverted into mountain reservoirs, the withdrawal of so much water would greatly lessen, if not altogether prevent, the floods. In advocating a plan of this character they have failed to outline any practical way in which it can be done. It is not likely that storage reservoirs will ever be built for the sole purpose of preventing floods. The cost will be prohibitive. This may be illustrated by reference to the Sacramento River in California. This river is quite small in comparison with others subject to floods, but to have provided storage for the discharge of this stream below the mouth of Feather River for twenty-four hours on March 19, 1907, would have cost at least $20,000,000. When one remembers that this flood lasted for four days with extremely high water, both before and after this period, the magnitude of the undertaking is apparent. Furthermore, the rapid filling up of such reservoirs with silt borne by flood waters would gradually reduce their capacity. In nearly every case experienced hydraulic engineers are of the opinion that for purposes of river control it would be much more economical to provide a passageway for flood water by means of levees and channel excavations than to attempt to hold the water behind costly dams at the higher elevations.

If it is intended to build storage reservoirs to provide water supplies for the irrigation of lands and at the same time utilize them as occasion arises for the prevention of floods, the plan is not feasible. There would be diverse interests that could not be brought together. The landowners in the more elevated portions of a drainage basin would want storage reservoirs solely for irrigation purposes. Those in the lower portions of the basin would want them most for protection against overflow. One and the same reservoir could not well serve both purposes. The irrigator would never consent to take chances on a half-filled reservoir for the sake of keeping it empty to provide for a flood which might never come.

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IRRIGATION LAWS AND ORGANIZATIONS.

By R. P. TEELE,
Office of Experimental Stations.

WHAT AGENCIES ARE DEVELOPING IRRIGATION.

INDIVIDUAL.

The early irrigation works were built almost entirely by individuals or groups of individuals working together, who built small works, taking water from streams for the watering of their own lands. This type of development is past in most arid sections, because the opportunities for it are fully utilized, but in the semiarid region it is probable that large areas will still be watered in this way, as the advantages of irrigation in sections where crops can be grown without it are realized. Irrigation by individuals, however, has still a very large field where water is pumped from wells or stored in small reservoirs, which are filled from the torrential flow of streams or with rainwater collected from adjacent lands.

Most large ditches cover more lands than can be irrigated by them, but they raise the level of the ground water to such an extent that it can be pumped to the surface within the limits of allowable cost. A great many such pumping plants have been, and are being, installed by individuals, and there is great opportunity for extension along this line. The pumping of water from the soil in this way produces a double use of water, for the source of supply is water already used for irrigation. While in some sections of southern California and southern Texas large areas are irrigated with water pumped from underground sources, it is generally true that this source is just beginning to be utilized. This field is peculiarly adapted to development by individuals because of the many advantages of pumping water at the point of use, the greatest of which are the saving of the expense of building conduits to carry the water to the place of use and the avoidance of all losses of water in transit, which losses are very large if water is carried in earthen ditches, and which can be prevented only at heavy expense. It is true that small pumping plants are not so efficient as larger ones, and this is especially true of engines of all types. However, the long-distance transmission of electric power makes it possible to develop power in large central stations where conditions are especially favorable and distribute it to individual or neighborhood pumping plants. In this way the cost of power is reduced to a minimum, as the electric motors and pumps used by the farmers require almost no attendance, leaving the farmer free to attend to his other duties.

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The storage of storm water in small reservoirs is another field of great possibilities which belongs naturally to the individual and which has been barely touched as yet. The opportunities for such development are greatest on the plains where stock raising must always be the principal industry. In the past, great areas have been unused because flocks and herds must be kept within the reach of water. The storing of the storm water makes it possible to use great areas formerly unavailable, and it also enables the stockman to raise forage for feeding during winter storms, thus preventing the losses due to starvation when winter feed is not supplied, which losses often reach 10 per cent in a single storm. The greater part of the plains area is beyond the reach of water from streams, and underground water is at such great depths that the cost of pumping it to the surface is prohibitive, but these plains have innumerable ravines and depressions in which storm water can be stored at small expense.

The small precipitation of the plains for the most part comes in heavy showers which run off quickly, causing floods in the usually dry drainage channels, which do great damage. If this water can be held back in reservoirs they will serve the triple purpose of providing stock water, irrigation water, and checking floods. This work has been begun and has proven its value, as shown by instances cited in a report on this subject published by the U. S. Department of Agriculture.[a] No other one thing promises so great returns from the Great Plains lying to the east of the Rocky Mountains.

Since storage dams are always a menace to land lying below them, the construction of such dams should be under the supervision of competent local officials who should be empowered to prescribe rules for their construction, to inspect them during and after construction, and to order necessary changes and repairs. The National Government is aiding in this work through the United States Department of Agriculture, which has published bulletins showing the possibilities of such storage, the returns secured, and the methods of construction which should be adopted to insure the permanency of dams and protect the land below them from damage. Any law enacted by the General Government providing for the leasing of grazing areas should provide in some way for the encouragement of the building of storage reservoirs and should permit the cultivation of a small part of each leasehold.

CORPORATE.

Following the individual and partnership ditches, which watered a single farm or a few neighboring farms along the rivers, came the large ditches built by corporations to water the higher lands of the river valleys of the arid region. These corporations have built most of the large ditches now in use. The great increase in the value of desert lands, when water was supplied for their irrigation, attracted large amounts of capital into this field in the years immediately preceding and following 1880.

The prevailing type of corporation was a company which built the irrigation works and sold water rights to settlers, the expectation being that the sale of water rights would repay the cost of construction with a good profit, and leave the company still in possession of

[a] O. E. S. Bul. 179—Small Reservoirs in Wyoming, Montana, and South Dakota, by F. C. Herrmann.

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the works and franchises, the contracts with the water users providing for the payment of annual charges to cover the cost of maintenance and operation. The promoters thus expected to secure the return of their entire investment, retain the property, and make it pay interest on its cost. Almost without exception these companies have been financial failures, but agricultural successes. The lands were settled slowly, so that water rights were not sold; maintenance charges were based on the entire acreage to be irrigated, and the payment from the small areas watered did not begin to cover the cost of maintenance and interest charges. Meanwhile the farmers prospered, and eventually the lands were settled but not until interest and upkeep had brought financial ruin to the companies building the works.

A modification of this plan which became very popular was a provision that when all or a large percentage of the water rights represented by a canal were sold the works were to become the property of the water-right holders, to be maintained and operated by them. The water-right contracts were to be exchanged for stock in a new company which should take over the works and operate them. This has not proven much more successful, from the standpoint of the original investor, but it has resulted in making this the prevailing type of canal company throughout the arid region. By far the larger part of the existing irrigation works in the arid region is owned and controlled by stock companies, the stock of which is in the hands of the water users. The laws of all the States accepting the conditions of the Carey Act, and the reclamation law, providing for the construction of irrigation works by the General Government, provide that the works built shall be turned over to companies of this type. In general, then, this may be said to be the standard type of irrigation corporation. There are some companies which supply water to customers without the sale of water rights, securing their entire returns from the annual charges. These are most common in the rice districts of Louisiana and Texas, although they exist in other places.

In all of the arid States canal companies are given the right of eminent domain, and the States have the right to regulate charges, usually through the county commissioners.

There is still considerable construction being carried on by canal companies of the types just described, but the greater part of present construction is done by quasi-public corporations under state control, or by the National Government under the reclamation law.

STATE.

In two instances States have undertaken directly the construction of irrigation works, but in both instances the undertakings have been abandoned. Colorado sought to utilize its convict labor in the building of ditches, but abandoned the attempt before completing any works. Montana attempted to build its own ditches under the Carey Act, but here, too, direct state construction was abandoned before any projects were completed.

The arid States do, however, aid in the development of irrigation under two classes of laws: Irrigation district laws, and laws accepting the conditions of the Carey Act.

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IRRIGATION DISTRICTS.

Irrigation districts are given the power, when properly organized, to issue bonds to secure funds for the purchase and construction of irrigation works; to levy and collect taxes for the maintenance and operation of these works, for the payment of interest, and for the creation of sinking funds to pay off the bonds issued. They are organized under public supervision, and provision is made for the establishment of the validity of their organization. The bonds and the taxes levied are liens upon the lands of the districts in the same manner as are county and state taxes. Usually county treasurers are ex-officio treasurers of irrigation districts within their respective counties.

The irrigation district laws of the several States are similar in a general way, but differ much in detail. They provide that the lands susceptible of irrigation from a common source and by the same system of irrigation works may be organized into an irrigation district. Usually the organization of an irrigation district is to be initiated by petitioning the county commissioners of the county in which a majority of the lands are situated. When the plans have been formulated and the proposed boundaries have been fixed an election is held to decide upon the organization of the district. The qualifications of electors differ, the Colorado law being as follows:

> All persons shall be entitled to vote who are resident freeholders of agricultural lands within said district, or who are owners of lands to the extent of 40 acres or more within said district and reside within any county into which any part of said district shall extend, and who are qualified electors under the general election laws of the State, and who shall have paid property taxes on property located within the district during the year preceding any such election. (Laws of 1907, p. 488.)

The majority required to carry such an election also varies in the different States. In Colorado a majority vote only is required for either the organization of a district or the issue of bonds. In Idaho a two-thirds vote is required for either purpose.

The manner of assessing the cost upon the lands also varies. In Colorado it is a flat rate per acre; while in Idaho the cost is apportioned in proportion to the benefits received, while the cost of maintenance and operation may be provided for by tolls or by assessments on the lands, or by a combination of the two.

The bonds run twenty years. Only the interest is payable during the first ten years. At the end of the eleventh year 5 per cent of the bonds mature; at the end of the twelfth year, 6 per cent; at the end of the thirteenth year, 7 per cent; fourteenth year, 8 per cent; fifteenth year, 9 per cent; sixteenth year, 10 per cent; seventeenth year, 11 per cent; eighteenth year, 13 per cent; nineteenth year, 15 per cent; and twentieth year, 16 per cent.

Irrigation-district laws have been used principally for the purchase of works already built and for their enlargement or extension. They are not adapted to the construction of new works in the arid region because a large part of the lands to be reclaimed belongs either to the General Government or the States and can not be taxed for irrigation-district purposes, and consequently can not become security for the bonds of districts. To obviate this objection as far as pos-

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sible Idaho provided by law that state lands included within irrigation districts should be liable for district taxes, and that the taxes paid by the State should be added to the price of these lands when sold by the State. Idaho provided also for the purchase of irrigation-district bonds by the General Government under the Reclamation Act. However, neither of these provisions has had opportunity to demonstrate its utility.

They suggest, however, the possibility of adapting these laws to the development of new lands and point out an existing weakness in other forms of organization. The building of a canal from which a tract of land can be supplied with water greatly increases the value of the land. Under the usual forms of canal organization the owner of land under a canal may or may not purchase water rights, but the value of his property is greatly enhanced by the mere possibility of securing water. Yet there is no way in which he can be made to contribute to the cost of the irrigation works. This condition was one of the primary reasons for the passage of irrigation-district laws. Under them all private lands susceptible of irrigation from the work built must contribute to the cost. The taxes levied by the district can not be met from unimproved lands, and improvement of all lands covered is therefore forced. Lands owned by the State or General Government can not, however, be made to contribute. It seems that both the States and the nation should provide for the payment of district taxes on their lands, with proper provision, of course, for approval of plans by public officials, for the addition of taxes paid to the price of the public land, and limitations upon the percentage of public land in the total area of a district.

District laws have a further advantage in that payments on the bonds for the first ten years are limited to the interest, whereas other laws require that payments on the principal begin at once. Often the preparing of land for irrigation costs as much as the irrigation works and is a heavy burden on the settler during the first year of his settlement. Under district laws he is free to meet these expenses and pay the cost of his irrigation works when he has become established.

District laws place the control of irrigation works in the hands of officials elected by the owners of the lands watered, the difference between this control and that of the stock companies previously described being that in the district all landowners have equal voice in the control of the works, while in the stock company the stock and the influence of its holder are usually in proportion to the acreage watered.

THE CAREY ACT.

Under what is known as the "Carey Act" (an act making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1895, and for other purposes, 28 Stat., 372–422) large areas have been developed under a sort of cooperation between the nation, the State, corporations, and individuals. The General Government gives the lands to the States on condition of their reclamation; the States enter into contracts with corporations to reclaim these lands, and sell the lands to individuals.

Section 4 of the act above mentioned, which constitutes the so-called "Carey Act," provides for the granting to each of the arid

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States free of cost for survey or price such areas of desert land, not to exceed 1,000,000 acres, "as the State may cause to be irrigated, reclaimed, occupied, and not less than 20 acres of each 160 acres irrigated by actual settlers," within ten years from the passage of the act.

In 1896 Congress passed an act providing that a lien might be placed on these lands to secure the payment of the cost of the irrigation works built to reclaim them, and in 1901 the time limit contained in the original act was removed, the law providing that the ten years within which lands must be reclaimed "shall begin to run from the date of approval by the Secretary of the Interior of the States' application for the segregation of such lands," and giving the Secretary of the Interior authority, in his discretion, to extend this time for an additional five years.

Further modification in 1908 granted to each of the States of Wyoming and Idaho, which had applied for most of the original 1,000,000 acres allotted to them, an additional 1,000,000 acres.

The conditions of this act have been accepted by the following States: Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming.

The plans adopted by the States for carrying out the reclamation of these lands vary in details, but are similar in their general outlines. The system adopted by the State of Wyoming is described by the state engineer as follows:

> The company proposing to carry on such development first makes its surveys and plans for this work; then secures the necessary permits from the state engineer's office; then makes its request and proposal to the state board of land commissioners, composed of the governor, the secretary of state, and the superintendent of public instruction. This request and proposal describe the lands that are to be irrigated and contain the proposition of the company to the State as to price of water rights and a permanent interest in irrigation works, the form of contract to be used, and other particulars. If the state board of land commissioners approves the proposition, maps and a request for the segregation of the lands are transmitted to the proper local land office. The lands designated are immediately withdrawn from entry, and the local land office submits the request to the General Land Office at Washington, where the approval of the Secretary of the Interior finally places the State in control of the land. The works are then completed by the company. The land can not be taken up until the settler shows the State that he has entered into contract with the company for a sufficient water right for his lands and a perpetual interest in the irrigation works, proportioned in the ratio of the area of his land to the entire tract to be reclaimed. When the irrigation works are completed, the state engineer makes an inspection, and if they are found to comply with the plans and specifications which have been already passed upon by him, the state board of land commissioners is so notified; whereupon the board makes a request to the Government that patent issue. The patent comes to the State, and the lands are sold and patent given the settler upon the payment of 50 cents per acre, the payments for water rights being made to the company building the works.

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The areas segregated and the areas patented to the States under the Carey Act up to July 1, 1908, as shown by the report of the Commissioner of the General Land Office, are as follows:

Segregations applied for under the act of August 18, 1894 (28 Stat. L., 372–422), and the acts amendatory thereof, with the action taken thereon, from the passage of the act to July 1, 1908.

[Areas in acres.]

State.	Selected.	Rejected, relinquished, etc.	Approved, not patented.	Approved and patented.
Colorado	50,807.94	5,704.95	54,102.99	
Idaho	1,180,566.17	265,828.94	662,254.00	156,954.90
Montana	104,587.98	2,792.53	83,498.54	18,296.91
Nevada	12,644.61	8,000.00		
Oregon	432,202.53	78,507.31	245,287.52	50,063.13
Utah	328,327.40	236,980.83	48,226.74	
Washington	155,649.39	155,649.39		
Wyoming	965,598.64	198,994.18	623,054.44	7,768.72
Total	3,239,284.66	952,458.13	1,716,424.23	293,083.66

Oregon segregation list No. 5, covering 58,344.57 acres, is pending before the Secretary on appeal from the decision of this office rejecting it.

Wyoming segregation list No. 27, covering 26,936.03 acres, was rejected by this office, which decision was affirmed by the department, but said decision has not yet become final.

As before stated, Congress in 1908 granted to Wyoming and Idaho, the only States which had applied for nearly the entire original allotment, additional areas of 1,000,000 acres each, indicating an intention to extend the area indefinitely as there is a demand for it. This seems to be a wise attitude.

The object of all our land laws has been to get the public lands into the hands of those who will make homes on them, rather than to secure a revenue from them. The Carey Act has proved well adapted to that end, and so long as it does this there seems to be no reason why there should be any limit on the area which may be selected by each State under this law.

The laws of all the States provide that when the water rights are sold and paid for the works shall become the property of the water-right holders and shall be turned over to a company composed of these parties to be maintained and operated by them, the provisions in this regard being similar to those of the reclamation law.

NATIONAL.

(Discussion of reclamation law omitted on account of its being under another department.)

DO PRESENT LAWS TEND TO PROMOTE IRRIGATION FULLY AND WISELY?

The object of all our laws relating to irrigation is to secure the establishment of the largest possible number of permanent prosperous homes on the lands of the arid region. All these laws must be judged by this standard. The establishment of homes in the arid region requires the cooperation of three parties—capitalists, farmers,

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and the public—and the interest of each must be guarded in any successful system of irrigation law. The capitalist must be given reasonable security for the return of his investment; the farmer must have a reasonable guaranty of a water supply and must be protected from exploitation by the capitalist; and the public must be assured that its resources will be economically used.

SECURITY FOR CAPITAL INVESTED.

As pointed out in the discussion of agencies now developing irrigation, the day of enterprises carried out by the individual is past. The construction of the large irrigation works necessary to store and divert the water of the large streams of the arid region requires the investment of large amounts of capital, and in order that this may be put into these enterprises it must have at least as great a degree of security as exists in other lines of investment. This security depends upon both the farmers and the public. The builders of irrigation works must be given a lien upon the property values created by these works sufficient to guarantee a return upon their investment, and in order that these property values may be stable and therefore good security, the water supply on which these values rest must be guaranteed within reasonable limits.

The three agencies under which the largest development is now taking place are: Irrigation districts, the Carey Act companies, and the United States Reclamation Service. Under the irrigation-district laws capital is secured by the sale of bonds, which are a lien upon the lands of the districts, and under the Carey Act the companies building the works sell water rights, the deferred payments on which become liens upon the lands. Under the reclamation law the Government secures itself by taking liens upon the lands. It seems, then, that under these laws capital is amply secured so far as the farmer is concerned, and the large amounts of capital being put into irrigation works under all these laws indicate that the security is considered sufficient.

This security is almost valueless, however, unless the water supply is reasonably sure, since the lands of the arid region are rendered valuable only by the use of water. This has been recognized from the earliest settlement of the arid region, and the legislatures and courts of the arid States and of the General Government have been trying from that time to this, to develop a system of laws which will render rights to water as secure as those to other forms of property. In order that this property may be as secure as other property, two things are essential: That all rights be defined, and that some effective system of protection be provided. There are in the arid region two systems of water law, one of which fulfills these requirements, and the other of which renders any such security impossible.

Certain States have recognized the common-law doctrine of riparian rights, which, in the very nature of the doctrine precludes any defining of rights. The riparian owner is held to have the right to a reasonable use of the water of the stream to which his land is riparian, which use must not interfere with a like use by all other riparian owners. What is a reasonable use at one time may not be at another time, and any riparian owner may at any time enlarge or change his

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use of the water, every change making necessary a new adjustment of use by all other owners. As a result, there can be no security of rights where riparian rights are recognized, except through monopoly created by the uniting of ownership in a single party. Some of these States have enacted laws providing for the condemnation of riparian rights, and this seems to be the only equitable way in which the handicap created by the recognition of riparian rights can be overcome.

Most of the arid States have either abrogated the doctrine of riparian rights or their courts have held that it never existed within their territories because of its inapplicability to arid conditions. These States allow the diversion of water from their streams for the irrigation of any lands, whether riparian or not. They have adopted the principle that "the first in time is the first in right," which in practice means that the one first using water from a given source has a right to continue that use to the extent of the original use, as against anyone taking water from the same source at a later date, and that when there is not water enough to supply all demands the latest user is first deprived of a supply, and so on, in order as the supply decreases. The carrying out of this system requires that all rights be defined as to both time and extent, and an administrative system to divide the water among those entitled to its use, according to their respective rights. These States have provided for the defining of rights either by the courts in a special procedure, or by administrative boards, with appeal to the courts. They have provided for either the granting of rights by the State or for the securing of rights by appropriation, which are later defined by the courts; and they have provided for the distribution of water in accordance with these decrees by state officials. This system gives the necessary security to water rights. The records of the state officials show what rights are already in existence; they show whether the stream flow is sufficient to satisfy existing demand, and whether there is more water to be secured by the builders of new ditches or reservoirs; and state officials distribute the water. There have been, of course, many crudities in court decrees, and injustice has been done in some cases, but the system is good, and should be maintained. One serious weakness has developed in this system. The courses of many of our large streams lie in more than one State, and the administrative system of a State can not extend beyond its boundaries. This weakness has been met so far by appeal to the United States courts. There has been strong demand for some administrative provision for the distribution of water from interstate streams, but no such provision has been made so far. The United States courts have uniformly upheld the doctrine of priority, regardless of state lines, and have protected the users in the lower States against later users in the upper States. A physical examination of our interstate streams leads to the conclusion that there is not likely to be serious conflict between the States on these streams. In most cases the physical conditions are such that users in the upper States can not do serious permanent injury to the users in the lower States.

In general, therefore, from the standpoint of the capitalist, the existing water laws of the arid States, except those which have recognized riparian rights, give the necessary protection to water rights.

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PROTECTION FOR THE FARMER.

As regards the water supply, the canal company stands in the same relation to the farmer that the State does to the canal company. There has not been, however, the same provision for the protection of the rights of the farmer. Many canal companies have agreed to supply water to far more land than their canals will serve properly, and have inserted in their agreements provision that whatever water their canals receive shall be prorated among all holders of water rights, and that they are not responsible for any shortage due to causes beyond their control or to shortage in the source of supply. A common provision in such agreements is that the company will not sell rights to more than the "estimated capacity" of its ditch, but this is little protection, because there is no limit put on the "estimate" of the ditch owner. While such provisions have worked many hardships on the farmers they have tended to an economical use of water, because farmers under canals supplying insufficient water have been compelled to practice a degree of economy which they might never have attained except under necessity. There should be legislation by the States making canal companies responsible for shortages due to overselling, because the new settler, coming into an arid region is in no position to determine for himself whether the company selling him a water right is in a position to furnish him a full supply.

As pointed out in the discussion of agencies developing irrigation, the prevailing type of ditch company is one in which the works ultimately become the property of the water users, and that irrigation-district laws, the Carey Act, and the reclamation law all provide for the control of the works by the water users. None of these laws protects him, however, from purchasing an interest in a canal which will not supply him with sufficient water. He guarantees his payments for these works with a lien upon his lands, but has no recourse if he is not supplied enough water to enable him to raise crops with which to meet his payments.

THE GUARANTY OF ECONOMICAL USE.

Throughout the arid region, except in the States which recognize riparian rights, the extent of a right to water is the quantity which has been put to a beneficial use, and the right ceases to exist when the use is abandoned. In some States the period of nonuse which constitutes abandonment is fixed by law, while in others this is left to the courts. These laws, if properly enforced, effectively prevent the holding of rights unused for speculation, as land is so often held.

These States have also laws prohibiting the waste of water, and as a rule the officials charged with distributing water are required to prevent waste, but in practice this is extremely difficult, since the officials can not patrol the ditches, but must turn out to each canal the water which its owners demand within the limit of their rights. These laws do, however, usually prevent absolute waste. But between positive waste and the most economical use there is a very wide margin for saving, which can be realized only by making it to the interest of the water user to be economical.

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Considered from the standpoint of their influence on the economical use of water, the laws of the arid States fall in two classes—those which allow the acquirement of rights to fixed quantities of water and those which allow the acquirement of rights to water sufficient for fixed areas of land. It has been found that the granting of rights to fixed volumes of water with the privilege of using this water on as much or as little land as desired brings about the most economical use of water. Having a certain volume of water, it is to the interest of the owner to secure as large a return as possible from this supply. On the other hand, the water user who is entitled to sufficient water for a certain area has no incentive to economy. His saving brings him nothing, but goes to some one else. Under these circumstances he can not be expected to spend time or money in saving water, as he would do if his efforts enabled him to water more land and thereby increase his returns.

The fear of the accumulation of rights in the hands of nonusers or "water lords," and of their exploitation of the water users has led to the enactment of laws attaching rights to particular tracts of land, to the prohibition of the ownership of water rights apart from the land on which the water is to be used, and to the limiting of rights to the needs of these areas. But in practice it has not proven satisfactory. It has been found necessary to provide for the transfer of rights from the areas in connection with which they were acquired to other lands, the needs of which may or may not be the same as the needs of the areas from which the rights are transferred, thus rendering all rights uncertain as to quantity, and encouraging the liberal use of water in order to be sure and always have enough. It has been shown in the preceding discussion that there has been no tendency to "water lordism," but that the prevailing type of canal organization is the stock company composed of the water users, while all the laws under which development is now taking place provide for placing the ultimate ownership and control of irrigation works in the hands of the owner of the lands served. It is believed, therefore, that the reasons which brought into existence the laws attaching rights to definite areas of land and measuring them by the necessities of these lands have ceased to exist if they ever did exist. It is believed that the only system which can be expected to lead to the economical use of water is the limiting of rights to definite quantities of water, leaving the water-right holder to use this on as much or as little land as he will.

UPON WHAT MODIFICATIONS OF LAW WILL THE BEST PERMANENT DEVELOPMENT OF IRRIGATION SYSTEMS DEPEND?

Modifications of existing laws have been suggested in the preceding discussion. These suggestions lead to the following definite recommendations:

FEDERAL LAWS.

Limited areas of public lands within the area of irrigation districts should be made liable for irrigation-district taxes, the taxes thus paid to be added to the selling price of the lands.

The provisions of the Carey Act should be extended to the Territories, and the limit of the area which may be selected by each State should be removed.

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The reclamation law should be amended by providing for extensions of time for payments on water rights whenever a full supply of water is not available, and for release of mortgages in case the shortage is permanent.

STATE LAWS.

The law of riparian rights, so far as it is recognized in the arid region, should be abrogated, allowing the use of water on all lands, whether they border on streams or not. In this, vested rights should not be injured, but should be condemned for the public good. A permanent settlement of rights seems to be impossible until this is done.

Those States which have not already done so should provide for the defining of existing rights to water, for the orderly acquirement of rights in the future, and for the division of the water of streams among those entitled to its use by public officials.

Laws should be enacted prescribing severe penalties for selling rights to more water than can be supplied, since settlers have no means of ascertaining the ability of a canal company to fulfill its contracts.

All rights to water should be based on quantities rather than areas, since only in that way can economical use be secured.

State lands within the limits of irrigation districts should be made liable for district taxes, with proper limitations as to the proportion of the whole area which may be state lands, and for approval of district plans by state officials; the taxes paid being added to the price of the lands when sold.

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UNDERGROUND WATERS.

By W. C. MENDENHALL,
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Underground waters constitute one of the three natural subdivisions of precipitation. These subdivisions are evaporation, surface run-off, and percolation. That part of the precipitation which passes below the soil surface by seepage into the soil pores becomes thereby a part of the body of underground waters. Eventually it is returned to the air to begin again its circuit through the air and back to earth. This return to the air may be accomplished very quickly or very slowly. Capillarity and evaporation may withdraw the earth moisture and return it to the atmosphere before it has reached any considerable depth in the soil mantle, or it may pass beyond the reach of these forces and begin a journey through the soil pores or the rock masses that may continue for a few hundred feet or a few hundred miles. The waters may even accumulate in a porous rock mass and may remain there stored and practically motionless for centuries or for geologic epochs. All of that portion of the precipitation that is absorbed and remains underground for either a long or a short period, following a long or a short course, constitutes the ground water. There is, in addition, a certain amount of original water, either magmatic or included with the sediments at the time of their deposition. The aggregate quantity of this is undoubtedly very great, but as it is in general inaccessible to man, little attention need be given it in a discussion of water as a resource.

An estimate of the quantity of surface waters is a large but a relatively simple problem. It can be solved by the patient application through long periods of well-determined engineering methods. The resulting estimates, since they are those of the engineer and the mathematician, are correct within a limited percentage of error, because all the factors of the problem are capable of close determination. But although the quantity of surface waters is measurable, its maximum possible use is not rigidly determinable, because that problem contains a number of variable factors. Man's mastery over the mechanic arts is constantly increasing. That which is impossible to him to-day becomes possible to-morrow. Furthermore, economic controls are constantly shifting. A water power that is not available this year, not because of unsolved mechanical problems, but because of cost, may be easily available next year, because a railroad has been built, or a mine has been opened, or population has shifted. These are things that neither the mathematician nor the economist can predict. They introduce into the problem of determining the

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possible future use of any resource a factor so variable that the result is of doubtful value. Suggestions only can be made; rigid determinations are not possible.

As to ground waters, neither the determination of the total quantity nor of the maximum use is capable of close solution. The first involves general estimates of factors not directly measurable, such as the percentage of pore space in deeply buried and inaccessible material, soils, and rocks. These estimates must be made by the deductions of an inexact science, geology, instead of through the measurements of an exact science, engineering. The same variables enter into the determination of the maximum possible use of ground waters as into the maximum possible use of surface waters, namely, different and constantly shifting economic controls. It may be highly profitable to pump ground waters 500 feet vertically for the irrigation of citrus lands in southern California whose product is worth $250 per acre per year, whereas it may not be possible to pump 50 feet vertically in another locality, where the products are not worth $10 per acre per year. Notwithstanding, some such crude estimate as may be made of the quantity of these resources is helpful, since it gives us a concrete conception of the amounts with which we are dealing.

QUANTITY.

Estimates that vary widely have been made as to the total amount of this ground water. These estimates range from an amount sufficient to cover the earth to a depth of 96 feet (Fuller) to an amount sufficient to cover it to a depth of 7,500 feet (Delesse). The lower estimate is the later and may be regarded as of the greater value. The determination of the total quantity of underground water in existence, however, while a question of scientific interest, is of no practical moment, since only a very small proportion of the total is accessible to man and can therefore be made use of by him. And again, of the relatively small amount that is within reach, only that proportion that, if withdrawn, will be restored annually can be utilized, because, obviously, withdrawals in excess of this mean reduction of the principal and eventual bankruptcy.

Hence, although impressive estimates of the total may be made—as, for instance, the statement that there are 600 cubic miles of potable ground waters beneath the State of Florida, 800 cubic miles in the Great Central Valley of California, 1,000 cubic miles in the Dakota sandstone aquifer, and 10,000 cubic miles in the sediments of the Atlantic and Gulf coastal plains—these statements are not merely valueless, they are sadly misleading, because, if issued without explanation, the inference would follow that such a tremendous amount of water could be extracted from these districts and used by man. This inference is wholly unjustified for a number of reasons. In the first place, only a limited although variable percentage of the water that saturates those parts of the rock or soil masses that are within reach of pumps can be extracted in development; the remainder, much the larger proportion, being capillary and subcapillary, is not capable of extraction in any commercial way.

Again, these estimates of total ground waters include those at great depth, utterly beyond the reach of any pumps or known devices for their recovery. And, finally, of the very small proportion of the total

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that can be brought to the surface and made useful to man, only an amount should be taken out that is equal to the annual restorations; otherwise there will be a gradual depletion of the supply and a corresponding increase in the cost of the product. Hence, as a practical people, we are not in the least concerned with the total quantity of ground waters, but only with the possible annual accessions to the total, for this controls use.

USE.

The use of ground waters in a limited way for domestic and farm supplies is well-nigh universal. Municipal use, although not so general, is also extensive; whereas use for irrigation, confined, of course, to the arid and semiarid States, has begun to attract attention only since power development, either by the utilization of the energy of running water or by means of small power plants of the steam or internal combustion type, has become general. With the imperfect data at hand it is not possible to estimate the total volume of ground waters now used throughout the United States, but it is believed that in Florida at least 2,000 second-feet are developed and in California more than one-half as much. The development in these two States, therefore, representing as they do more than the average development in the East and the West, is about 3,000 second-feet. Florida and California include about 7 per cent of the area of the United States. If the development throughout our domain can be regarded as on the average one-half as intense as in these two States, the total ground waters used if united in one stream would equal twice the volume of the Potomac at Point of Rocks, Md., in 1906, with a drainage area of 9,650 square miles, or if a smaller factor is used and the average intensity of development be regarded as one-third that of the two States named, we reach the conclusion that the ground waters now in use would make a river the size of the Colorado at Yuma, Ariz., with a drainage area of 225,000 square miles. Expressed in still another way, this volume is equal to somewhat less than 1 per cent of the total stream flow in the United States. It is to be clearly understood that this represents only artificial development, a direct product of man's activity, and does not include the natural springs which represent the unassisted return of ground waters to the surface. To these is due a very large although undetermined proportion of the low-water flow of all our streams.

PRESENT TENDENCIES.

One of the late phases of the irrigation movement involves the use of ground waters for this purpose. This movement has been inspired by the success of certain communities that have developed such waters and reclaimed a large acreage by their use. The southern California communities, one-half of whose irrigation is accomplished in this way, illustrate what can be done. In the San Joaquin Valley development of this type is under way and will inevitably be greatly extended. Three hundred second-feet of ground waters are now used there; probably 3,000 second-feet are available and colonies are being continually established and individual settlers are constantly entering the valley who are reclaiming more and more acreage by the use of this resource. In other western valleys, as in Utah and in Arizona,

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development of the same type is under way. Among the famous ground-water districts is that of the Great Plains, east of the Rocky Mountains, underlain by the Dakota sandstone, that yields some of the largest flowing wells of the United States. Another important district includes parts of Minnesota, Iowa, and Wisconsin, beneath whose surface lie water-bearing beds older than the Dakota sandstone, but the beds are locally quite as important. In these latter States irrigation is not practiced, but the ground waters are of great importance as sources of domestic and municipal supplies. In the Eastern and Southern States, those of the Atlantic and Gulf coastal plains are most favorably situated in regard to their ground-water supplies and in them development is more intense than elsewhere in the East. Attention has already been called to Florida, in which nearly 2,000 second-feet of ground waters are developed, nearly one-half of this amount being used for irrigation and domestic purposes. Mississippi, Louisiana, and Texas have abundant underground supplies extensively drawn upon in certain localities, but capable of much more extensive use. Data are not at hand for estimating the amount withdrawn at present.

WASTE.

Attention is usually first centered upon the use of ground waters by the development of flowing wells in areas where they may be secured. The advantages of a supply of this type are many. The waters usually cost little, they are protected from contamination, the output is regular, at least until development becomes too intense for the supply, and the quality is constant. But in regions in which flowing waters are used for irrigation and may be procured at shallow depths the resource is often shamelessly wasted. More wells are drilled than are needed and the water is used during but a small portion of the year, but is nevertheless allowed to flow with consequent reduction of head and depletion of supply and often in addition direct damage to the lands upon which it wastes. This waste is not so serious in humid regions in which the loss is quickly replaced by rainfall, but it goes on with equal recklessness in arid and semiarid sections in which the damage is irreparable. This waste is often in direct violation of state statutes, framed especially to prevent it. Where ground waters do not flow out upon the surface but are developed by pumping, waste does not take place, since the cost of production regulates automatically the amount of water withdrawn. Irrigation practice under these conditions is always superior, as the water user, paying for each gallon that he applies to his land, reduces this amount to the lowest effective quantity in order to save cost. Hence almost invariably better results are obtained with a lower duty in districts where irrigation water must be pumped than in those in which it flows.

In the humid regions ground waters—almost everywhere available—are particularly useful as sources of farm, domestic, and municipal supplies and for certain industrial purposes. They are especially beneficial and of particularly good quality in the coastal plain of the Atlantic and Gulf States and in the glaciated regions where the mantle of drift or of unconsolidated sediments forms a reservoir of great capacity, whose supply is rapidly renewed when

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drawn upon because of the abundant rainfall. Outside the coastal plain and the drift-covered areas conditions are variable, but generally they are inferior to those in the regions named, because the soil mantle over the rocks is often thin and irregularly distributed and in addition is frequently clayey and of small holding capacity. Within either of these regions there may occur synclinal basins of porous rock like the St. Peter sandstone and associated beds in Minnesota or the Dakota sandstone in the Great Plains, both of which form most important reservoirs. Usually, also, the fractured upper surface of whatever rock lies immediately below the soil carries a supply that may be drawn upon by town and farm wells.

IMPORTANCE.

The importance of these supplies in humid regions to the dwellers there is illustrated by Mr. Frank Leverett's careful determination of the fact that 75 per cent of the population in Michigan are directly dependent for water upon the underground supply, and since the constancy of the lakes and the flow of the streams upon which the remaining 25 per cent depend is also related to the ground waters, the importance of these is really greater than the given percentage indicates. A recent investigation of 19 counties in north-central Indiana again indicates the vital relation that ground water bears to daily life. Of 54 communities in these 19 counties having public supplies, 45 use wells alone and 3 others use both streams and wells. The urban population is therefore largely dependent upon the subsurface supplies and the rural population depends almost entirely upon them. It is estimated that in Florida 750,000,000 gallons of ground waters are used daily for town and country domestic supplies, while an additional 11,500,000 gallons are used by the cities and 500,000,000 gallons for the irrigation of tobacco, citrus fruits, and vegetables. One-half of the irrigation and the greater part of the city supplies in southern California, amounting to more than 300,000,000 gallons daily, are drawn from the sands and gravels that underlie the valleys, while in central California a smaller but nevertheless important draft is made upon the same source.

These available facts, selected from widely scattered localities, indicate clearly that in addition to the almost universal dependence of the rural population upon underground waters for culinary and domestic purposes, an important and growing use is made of them for irrigation and for town supplies. It is probable that it would be safe to apply percentages but slightly less than that determined in the State of Michigan to the entire United States, and to state that nearly 75 per cent of our population depends directly upon underground waters.

RELATION TO STREAM FLOW.

The indirect dependence of mankind upon ground waters is difficult to determine. The greater part of the low-water flow of those of our streams that have no large lakes, swamps, or glaciers in their drainage basins is sustained by the slow escape from soil and rock and vegetable mulch of water that is stored there during rains and the melting of snow. An amount equivalent to the low-water flow is also

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contributed of course during high-water periods, so that only that part of the annual run-off of ordinary streams that is represented by the excess of flood flow over low-water flow is discharged directly from the surface, without joining the body of the percolating waters. The remainder, for a longer or shorter part of its journey from the clouds to the sea, has been stored underground and the rate of its seaward passage thereby notably checked. The greater the proportion of precipitation within a drainage basin that joins the underflow, therefore, the more regular the streams of that basin. Areas of little or no underground storage are areas of violent floods and extreme droughts, while areas with a large proportion of underground storage are areas of slight floods and large and well-sustained low-water flow. Hence as a national policy all should be done that can be done to increase underground storage.

The factors that affect it favorably or adversely are many, and too few of them are within the control of man. Hence those that he can control should be used to the best possible advantage. Among these controlling factors are the character of the precipitation, the topography, including the steepness of slopes and of stream channels, the geology—that is, the character of the rocks and the soils—and finally the vegetation.

If the precipitation is violent and is concentrated within a short period, much less opportunity is afforded for its absorption than if the rain falls gently for a longer period. Brief violent storms are characteristic of our deserts where destructive floods are followed by long-continued droughts.

The effect of the topographic character of a drainage basin is obvious. There will be relatively little run-off from a perfect plain if the rocks or soil beneath it have absorptive capacity. In a region of steep slopes and stream channels of high gradient, on the contrary, water does not stand, and a comparatively slight precipitation will be followed promptly by a notable run-off, unless other favorable factors serve to prevent it.

The influence exerted by geology is also a powerful one. The type of rock, the presence and depth or the absence of soils derived from it, and the existence of a mantle of glacial drift often make the difference between a region well supplied with ground waters and drained by streams of regular flow and a region without ground waters and with most erratic and uncontrollable streams. Loose sandstones absorb water like sponges, to yield it slowly at some lower point, perhaps in a distant drainage basin. Cavernous limestones may offer tortuous underground passages through which water escapes slowly; the loose heaps of glacial débris permit but little surface escape, so thoroughly do they absorb the water that falls upon them. The deep mantle of decayed rock that covers many of our Southern States is equally effective in this respect. Polished glacial surfaces, on the contrary, such as exist in parts of the Sierra, shed water as effectively and promptly as a roof. Dense slates, fresh and unfractured granites, or close-grained metamorphic rocks absorb little or no water and contribute practically nothing to the underground supply.

Finally, the various cover growths are of the utmost importance in modifying absorption and run-off. Trees, brush, grasses, and grow-

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ing crops act in many ways to this end. Everywhere the roots, penetrating the soil and decaying there, leave little channels for the circulation of the water; on mountain slopes and rocky areas they hold loose fragments of rock by their binding root systems and prevent them from being washed away so soon. The crevices about the rock fragments which are thus held become little storage reservoirs. The trees aid in making these crevices by the prying action of their roots and by the disintegrating action of the vegetable acids that are yielded by their decay. The various growths build up a porous absorptive soil by the litter which they shed and the rock sand which becomes enmeshed in their roots, and they protect the soil which thus accumulates and prevent it being swept away. Finally, they interfere directly with run-off by the obstacles which their roots, stems, and fallen leaves and branches offer to the flow of water over the surface. In all of these functions the immediate escape of rains as sudden floods is checked and their absorption, to be slowly released later, is encouraged. It is because of the full recognition of this part that forests play in the conservation of ground waters and the regulation of run-off that engineers and geologists who have made a special study of ground-water supplies and their relation to surface waters are such earnest advocates of the conservation and extension of forest cover.

LIMITATIONS AND METHODS.

Something has been said of the wide extent of ground waters, of their enormous aggregate volume, of the direct dependence of man upon them, of their critical relation to the more obvious stream flow, and of the growing recognition of their latent value and industrial possibilities. A word should be added as to the danger of exaggerating their utility or their practical quantity in some places and the complex problems involved in their utilization.

They are ultimately dependent upon rainfall. Therefore, like surface waters, they are less abundant in arid than in humid regions, and when used there they will be less rapidly renewed. But because of the greater need more attention is paid to them in the dry than in the wet States; they are more vigorously developed there and there is more danger that they may be overdrawn.

Many gravel-filled valleys west of the Rocky Mountains contain both surface and underground waters, not enough of either alone to irrigate all of the tillable lands, but when both are used together much more valuable than when either is used alone. Often power can be developed upon surface streams and this power applied to the recovery of the earth waters that saturate the lower valley lands. This mountain water coming down to the lands from above is made to lift the underground water to the lands from below—a most admirable combination and one excellently illustrated in the case of the Santa Ana River in southern California.

A part of the water of this river is stored in a reservoir in the San Bernardino Mountains and the flow of the stream thereby regulated. After it escapes from the reservoir it is diverted through a power plant and electric power is generated. Below the first power plant it is rediverted and passed through a second power plant. Below this it is all distributed and used for municipal and irrigation pur-

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poses about Redlands and Highlands. The waters that return from the irrigation are recovered in springs and flowing wells and by pumping plants, a portion of the power developed higher up on the stream being used for the latter purpose. This recovered water is used for irrigation about San Bernardino and Riverside. A part of it reappears in the river above Riverside Narrows, where it is again taken out into a power ditch whose waters are returned to the river above Corona. A few miles below it is picked up by canals and distributed to the orange and deciduous groves about Anaheim and Santa Ana. The portion of it that returns there, by irrigation, to the ground water is once more recovered by the many pumping plants and flowing wells west of Santa Ana in the lower coastal plain.

A single drop of water in its progress from the mountains to the sea, a distance of only 100 miles, may thus be used as many as eight times for power and irrigation. This is an almost ideal use of water. The combination of power development and the recovery of underground waters to supplement the surface flow results in a minimum of waste and a maximum of economy. Development of this type is being rapidly extended now over parts of the West and will receive still further extension in the future.

But care must always be taken not to tax too severely the underground basins from which the water is drawn. They are not by any means inexhaustible. When rainfall is light, the quantity of water returned to the reservoirs each year may be small, although the quantity stored there is large. However large it may be, if more is withdrawn each year than is replaced, there will be gradual lowering of the ground-water level and ultimate disaster. Therefore, users of ground waters in arid regions must study carefully the effects of development in order to be sure that they are not prospering during the present at the expense of disaster in the future. Furthermore, in many sections where water is badly needed ground waters do not exist. Residents of such sections, urged on by their need, do not always realize this, and attempts that are hopeless from the beginning are made to procure them. Each field is a particular problem with its own solution. General rules have only a limited application.

RELATIONS TO OTHER RESOURCES AND TO CONSERVATION.

Ground waters and surface waters are, of course, intimately related. All usable ground waters were first surface waters, although perhaps only momentarily, and the greater part of them eventually become surface waters again after their journey underground is completed. It is thus that they sustain stream flow during dry periods and so are closely related to power development and to irrigation, both of which are much more successful with a sustained and regular than with an erratic run-off.

Practically all vegetable life depends upon the existence of ground water. It sustains our crops and our forests and is in turn protected by them through functions already outlined. Seventy-five per cent of our population depends directly upon it, and an important additional percentage indirectly. It is used in irrigation, in industry, in transportation, in all the many activities of life. But, being one of the resources that is constantly renewed by natural processes, we need only

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exercise reasonable care in our use of it to have it to draw upon perpetually. There are districts in the United States, fortunately few in number and small in area, where the ground waters are being extracted faster than they are renewed. There are other areas in which they are being contaminated and rendered useless or harmful by the careless discharge of industrial waste or sewage or brines from deep wells. There are still other areas in which, through the stripping of the natural cover growths, the annual accessions to the supply are materially reduced. These conditions must be met and remedied; then nature, through her annual rainfall, will repair the harm, as yet slight, that has been done.

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FLOODS.

By M. O. LEIGHTON,
Chief Hydrographer, United States Geological Survey.

A broad and comprehensive review of river-discharge records in the United States indicates unmistakably that floods are increasing. It is true that the opposite tendency may be shown on some rivers, while the records on others may indicate little or no change; but, taken as a whole, the rivers that reveal more intense flood tendencies so thoroughly dominate the situation that the conclusion above expressed must be inevitable.

It will be well to consider at the outset just what index may be used to determine the trend of flood tendencies. It is common in inquiries of this character to select and compare the highest stages attained in the several years of record, and because, perchance, higher floods may be shown in early years, many really competent persons have believed themselves forced to the conclusion that there is no increase in flood tendency. The actual height attained by the maximum flood each year is, however, a matter of small consequence in such considerations. A little reflection will show how this must be true. The precipitation, which is the ultimate cause of floods, takes three courses, only two of which are really important in the present discussion, namely, the course along the surface of the ground directly into watercourses, and that into the ground by percolation, with subsequent discharge into the rivers by seepage. In general terms it may be stated that the water which causes floods is that proportion of the precipitation which the earth does not absorb and which, therefore, must flow along the earth's surface. Now it is apparent that when precipitation becomes so intense and long continued that it practically saturates the ground the rain that falls thereafter must take the direct route and floods must necessarily arise. Therefore the height of great floods is fixed primarily by the intensity of precipitation and, as the amount of rain varies from year to year, now bountiful and again scanty in what seem to be fairly uniform cycles of years, the observation of an especially high flood during an early year compared with that of a much lower one during a recent year can give no index to flood tendency in any river. The real index is of more fundamental origin than the mere occurrence of high floods.

When the question "Are floods increasing?" is asked, the considerations involved are not those of height but those of duration and frequency. In other words, the question means, Are floods of more frequent occurrence and are there more days of flood than formerly?

Reverting for the moment to the discussion in the foregoing paragraphs, it is plain that floods will occur more frequently in response to a given rate of precipitation, if there are in the drainage area in-

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fluences that either inhibit or prevent the ready absorption of the rain by the ground, than they would if absorption were ideal. Such ideal condition assures complete absorption of all precipitation. A rain of a given depth in a unit's time—say 2 inches in one day—would surely produce a flood in a drainage area which was nonabsorbent. On the other hand, the same amount of rain would not change the river stage if the conditions enhancing absorption on the drainage area were ideal. Between these two extremes there are wide and varying conditions which tend to increase or to diminish the resultant floods from a given rainfall. In other words, the question "Are floods increasing?" means, essentially, Are the conditions of the surface of the ground in the river basins so changing that they render the ground less absorbent? If this be the case, it is clear that a much larger proportion of the precipitation would run directly off into the rivers than that which was so conducted at an earlier period.

There are five classes of agencies or conditions affecting the flow of streams. The first is climate, under which are comprised rainfall, evaporation, temperature, wind, and humidity. Although these are exceedingly variable from day to day and from season to season, the observations that have been recorded indicate that a period of years embraces all conditions, so that the mean of them may be considered fairly constant. There is very little evidence, except in special areas, that reveals any progressive and permanent change in climatic conditions. The second agency is topography, and the third geology, both of which may, for present purposes, be considered absolutely stable. The fourth is surface vegetation, which includes forest cover and cultivated land. This is subject to progressive change, according to the demands, conveniences, and usages of society. The fifth consists of artificial agencies, such as storage, reservoirs, and drainage, which produce rapid and marked effects on river discharge.

Therefore, the consideration of river discharge and especially of floods involves the appraisal of the effects of climate, vegetation, and artificial agencies. The other two agencies, being constant, may be left out of consideration. It is necessary to take account of these conditions in connection with all studies of progressive flood trend. This emphasizes the futility of many studies that have heretofore been made, in which not only have the extreme flood heights been the basis of determination, but there has been a total lack of consideration of climatic conditions, especially that of rainfall. A river, for example, may show a progressive decrease in flood frequency during a period of years. If that were taken alone it would indicate a decreasing flood trend; whereas, if the rainfall be compared progressively in the same manner, it might readily be shown that the flood trend was increasing rather than diminishing, because the precipitation was decreasing faster than the flood frequency.

The above considerations have been kept in mind in the study of flood frequency here presented. The accompanying diagrams, Nos. 1 to 8, inclusive, are the result of appropriate studies made of flood occurrence on rivers on which gages have been maintained for a long period, the longest, in fact, of which there are available and useful records in this country. Examination shows conclusively the increasing trend of flood occurrence and the cause thereof comes now properly into question.

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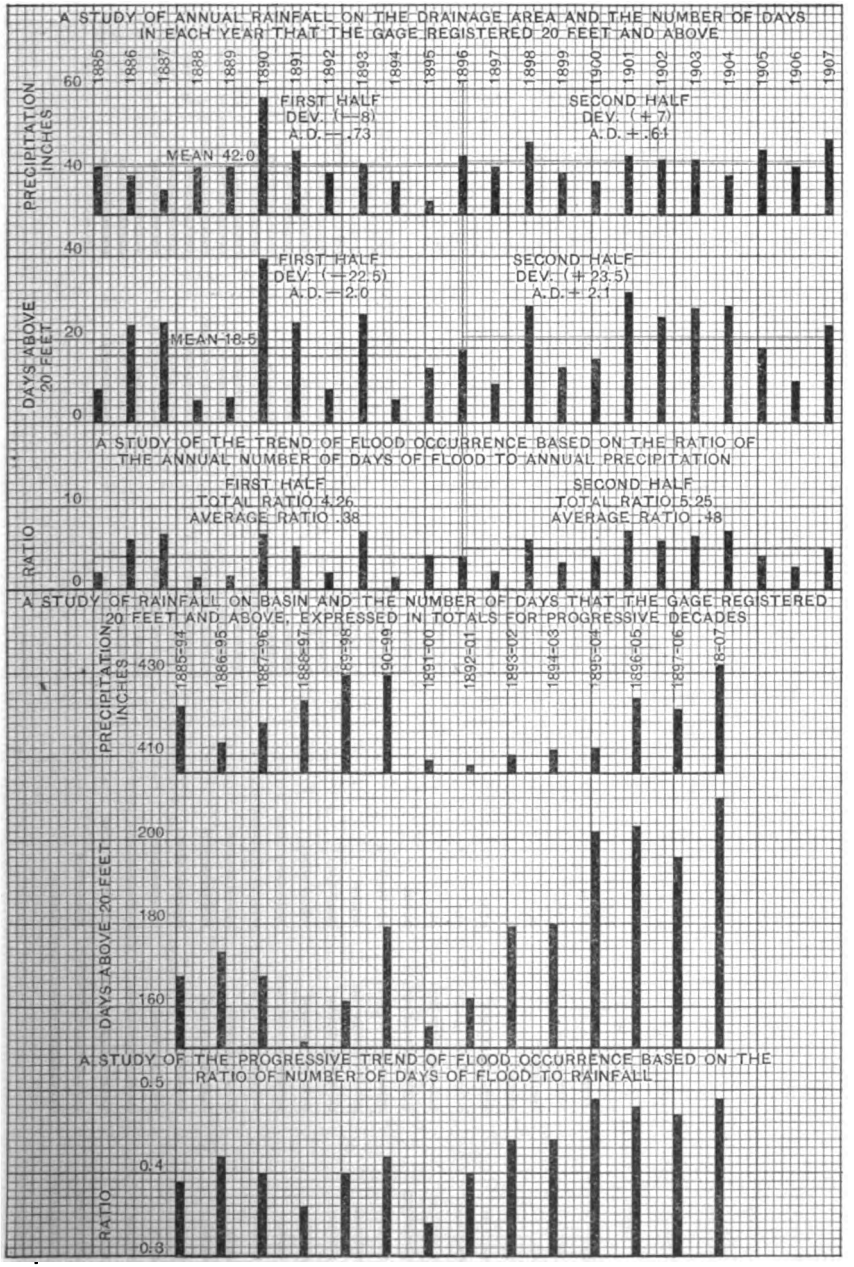
No. 1.

FLOODS ON OHIO RIVER AT WHEELING, W. VA. 1885-1907



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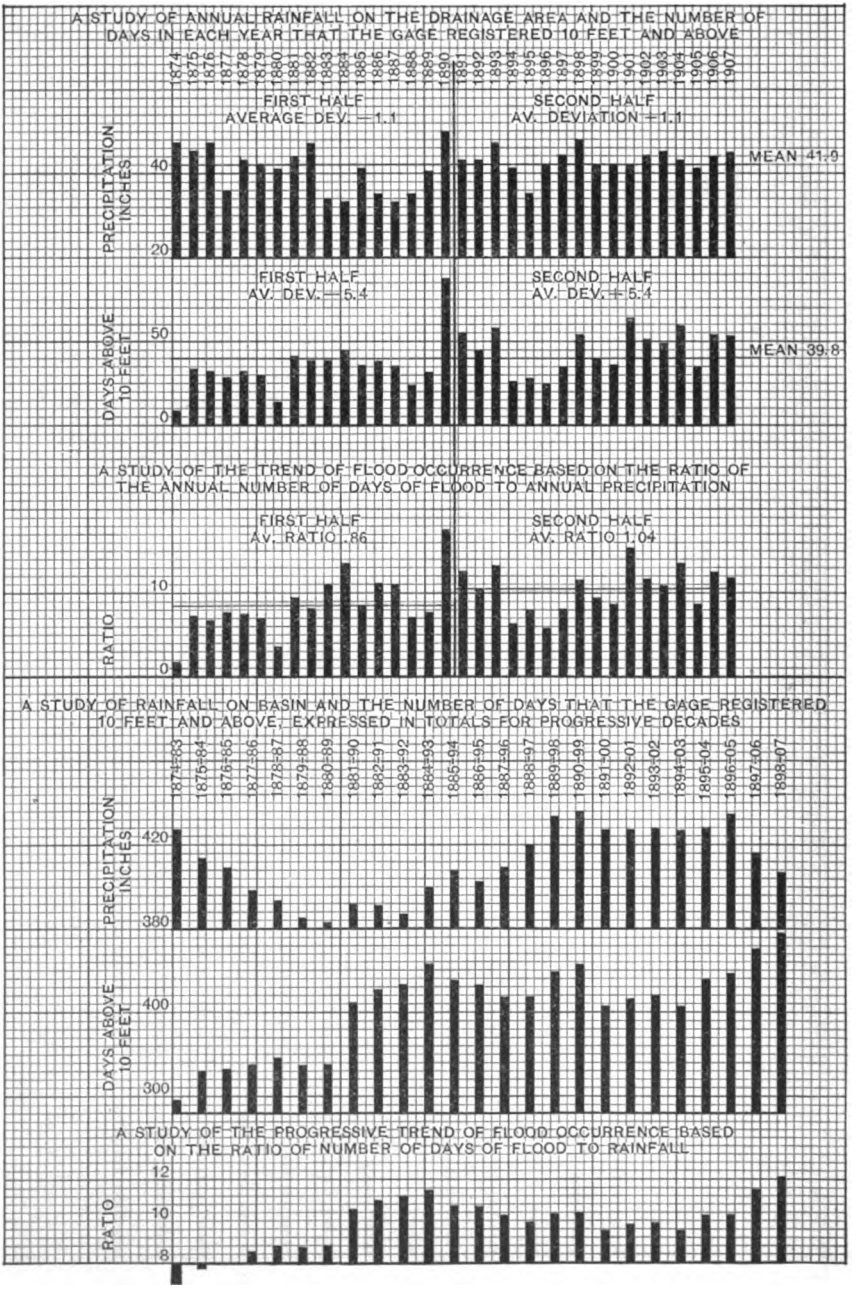
No. 2.

FLOODS ON ALLEGHENY RIVER AT FREEPORT, PA. 1874-1907.


A STUDY OF ANNUAL RAINFALL ON THE DRAINAGE AREA AND THE NUMBER OF DAYS IN EACH YEAR THAT THE GAGE REGISTERED 10 FEET AND ABOVE
1874 1875 1876 1877 1878 1879 1880 1881 1882 1883 1884 1885 1886 1887 1888 1889 1890 1891 1892 1893 1894 1895 1896 1897 1898 1899 1900 1901 1902 1903 1904 1905 1906 1907
FIRST HALF AVERAGE DEV. = 1.1
SECOND HALF AV. DEVIATION = 1.1
PRECIPITATION INCHES
40
20
MEAN 41.9
FIRST HALF AV. DEV. = 5.4
SECOND HALF AV. DEV. = 5.4
DAYS ABOVE 10 FEET
50
0
MEAN 39.8
A STUDY OF THE TREND OF FLOOD OCCURRENCE BASED ON THE RATIO OF THE ANNUAL NUMBER OF DAYS OF FLOOD TO ANNUAL PRECIPITATION
FIRST HALF AV. RATIO .86
SECOND HALF AV. RATIO 1.04
RATIO
10
0
A STUDY OF RAINFALL ON BASIN AND THE NUMBER OF DAYS THAT THE GAGE REGISTERED 10 FEET AND ABOVE, EXPRESSED IN TOTALS FOR PROGRESSIVE DECADES
1874-83 1875-84 1876-85 1877-86 1878-87 1879-88 1880-89 1881-90 1882-91 1883-92 1884-93 1885-94 1886-95 1887-96 1888-97 1889-98 1890-99 1891-00 1892-01 1893-02 1894-03 1895-04 1896-05 1897-06 1898-07
PRECIPITATION INCHES
420
380
DAYS ABOVE 10 FEET
400
300
A STUDY OF THE PROGRESSIVE TREND OF FLOOD OCCURRENCE BASED ON THE RATIO OF NUMBER OF DAYS OF FLOOD TO RAINFALL
RATIO
12
10
8

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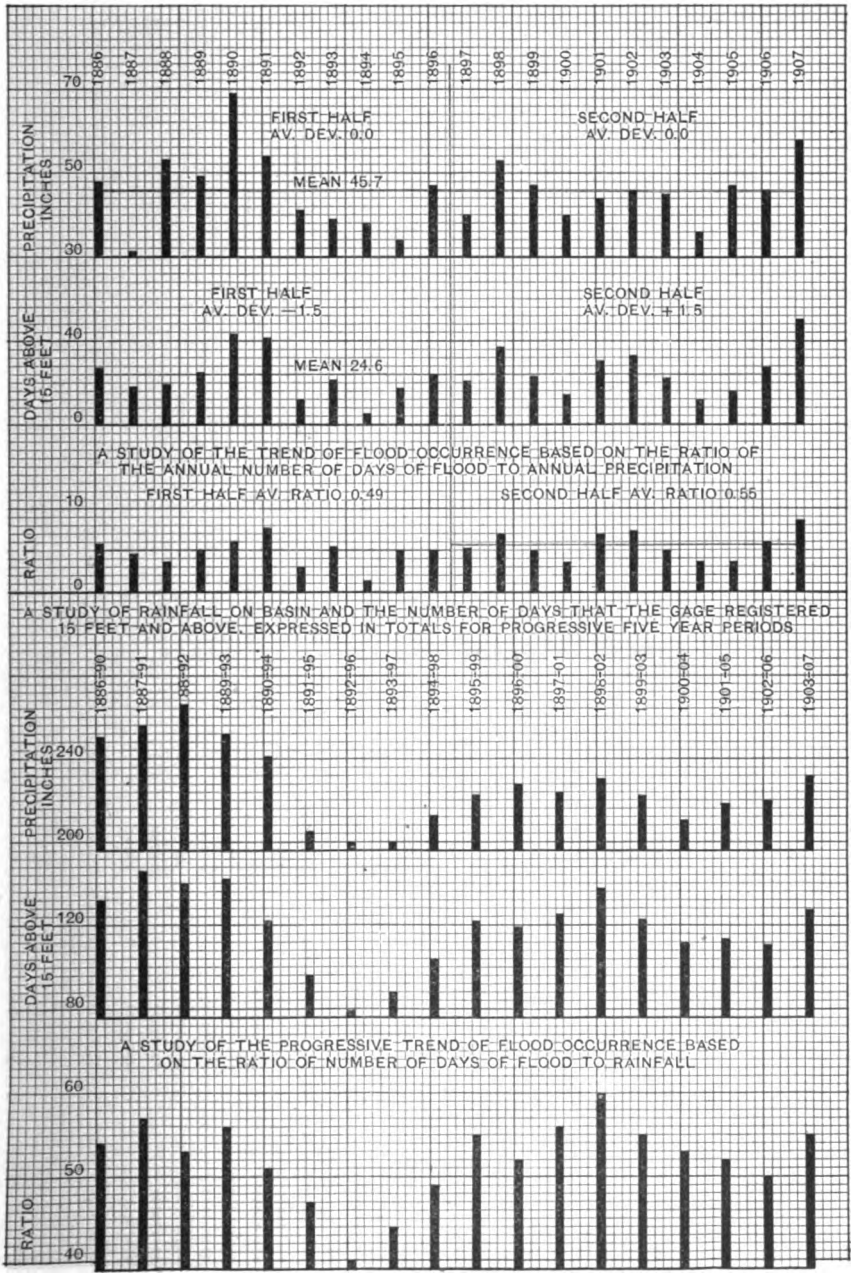
No. 3.

FLOODS ON MONONGAHELA RIVER AT LOCK NO. 4, PA. 1886-1907.


1886 1887 1888 1889 1890 1891 1892 1893 1894 1895 1896 1897 1898 1899 1900 1901 1902 1903 1904 1905 1906 1907
PRECIPITATION INCHES
70
50
30
FIRST HALF AV. DEV. 0.0
SECOND HALF AV. DEV. 0.0
MEAN 45.7
DAYS ABOVE 15 FEET
40
0
FIRST HALF AV. DEV. —1.5
SECOND HALF AV. DEV. + 1.5
MEAN 24.6
A STUDY OF THE TREND OF FLOOD OCCURRENCE BASED ON THE RATIO OF THE ANNUAL NUMBER OF DAYS OF FLOOD TO ANNUAL PRECIPITATION
RATIO
10
0
FIRST HALF AV. RATIO 0.49
SECOND HALF AV. RATIO 0.56
A STUDY OF RAINFALL ON BASIN AND THE NUMBER OF DAYS THAT THE GAGE REGISTERED 15 FEET AND ABOVE, EXPRESSED IN TOTALS FOR PROGRESSIVE FIVE YEAR PERIODS
1886-90 1887-91 1888-92 1889-93 1890-94 1891-95 1892-96 1893-97 1894-98 1895-99 1896-00 1897-01 1898-02 1899-03 1900-04 1901-05 1902-06 1903-07
PRECIPITATION INCHES
240
200
DAYS ABOVE 15 FEET
120
80
A STUDY OF THE PROGRESSIVE TREND OF FLOOD OCCURRENCE BASED ON THE RATIO OF NUMBER OF DAYS OF FLOOD TO RAINFALL
RATIO
60
50
40

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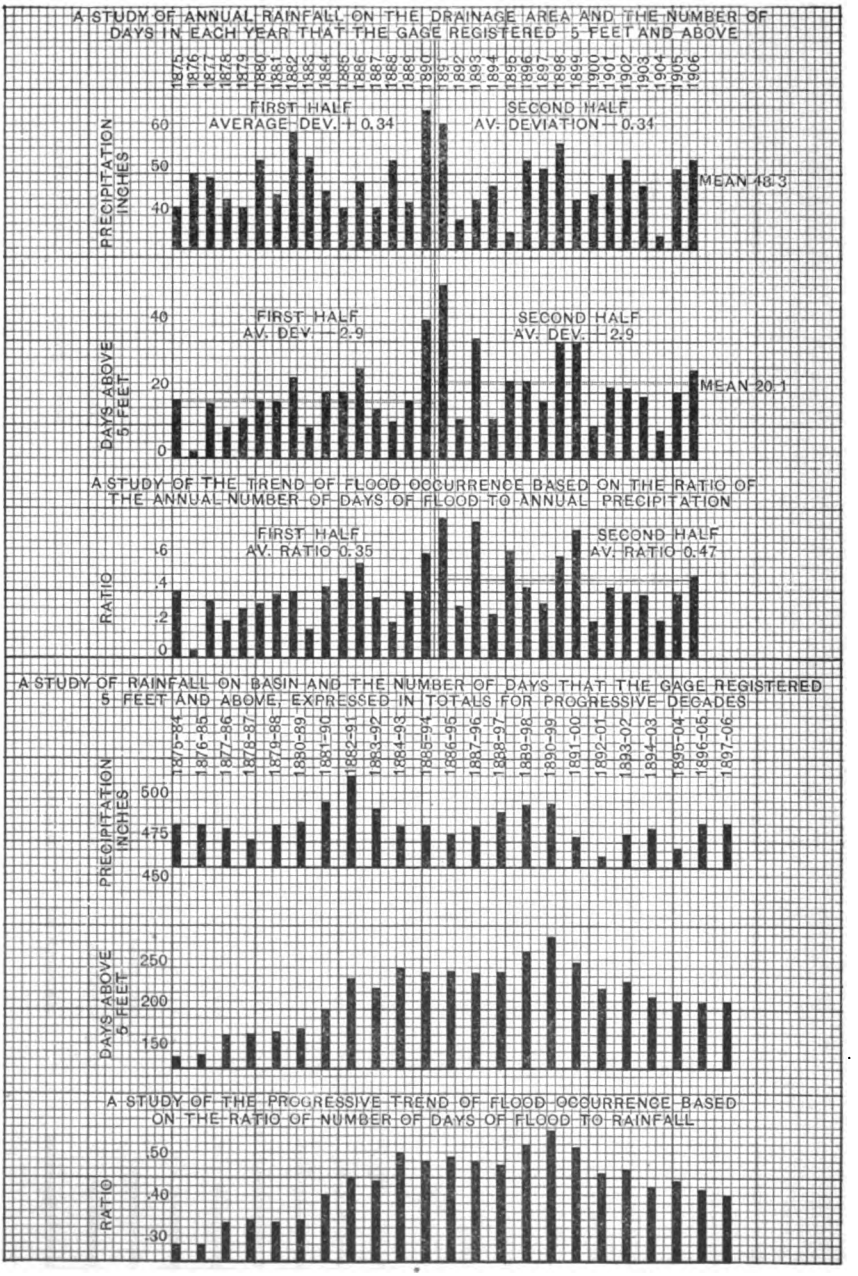
No. 4.

FLOODS ON YOUGHIOGHENY RIVER AT CONFLUENCE, PA. 1875–1906.


A STUDY OF ANNUAL RAINFALL ON THE DRAINAGE AREA AND THE NUMBER OF DAYS IN EACH YEAR THAT THE GAGE REGISTERED 5 FEET AND ABOVE
1875 1876 1877 1878 1879 1880 1881 1882 1883 1884 1885 1886 1887 1888 1889 1890 1891 1892 1893 1894 1895 1896 1897 1898 1899 1900 1901 1902 1903 1904 1905 1906
PRECIPITATION INCHES
60
50
40
FIRST HALF AVERAGE DEV. + 0.34
SECOND HALF AV. DEVIATION — 0.34
MEAN 48.3
DAYS ABOVE 5 FEET
40
20
0
FIRST HALF AV. DEV. — 2.9
SECOND HALF AV. DEV. — 2.9
MEAN 20.1
A STUDY OF THE TREND OF FLOOD OCCURRENCE BASED ON THE RATIO OF THE ANNUAL NUMBER OF DAYS OF FLOOD TO ANNUAL PRECIPITATION
RATIO
.6
.4
.2
0
FIRST HALF AV. RATIO 0.35
SECOND HALF AV. RATIO 0.47
A STUDY OF RAINFALL ON BASIN AND THE NUMBER OF DAYS THAT THE GAGE REGISTERED 5 FEET AND ABOVE, EXPRESSED IN TOTALS FOR PROGRESSIVE DECADES
1875-84 1876-85 1877-86 1878-87 1879-88 1880-89 1881-90 1882-91 1883-92 1884-93 1885-94 1886-95 1887-96 1888-97 1889-98 1890-99 1891-00 1892-01 1893-02 1894-03 1895-04 1896-05 1897-06
PRECIPITATION INCHES
500
475
450
DAYS ABOVE 5 FEET
250
200
150
A STUDY OF THE PROGRESSIVE TREND OF FLOOD OCCURRENCE BASED ON THE RATIO OF NUMBER OF DAYS OF FLOOD TO RAINFALL
RATIO
.50
.40
.30

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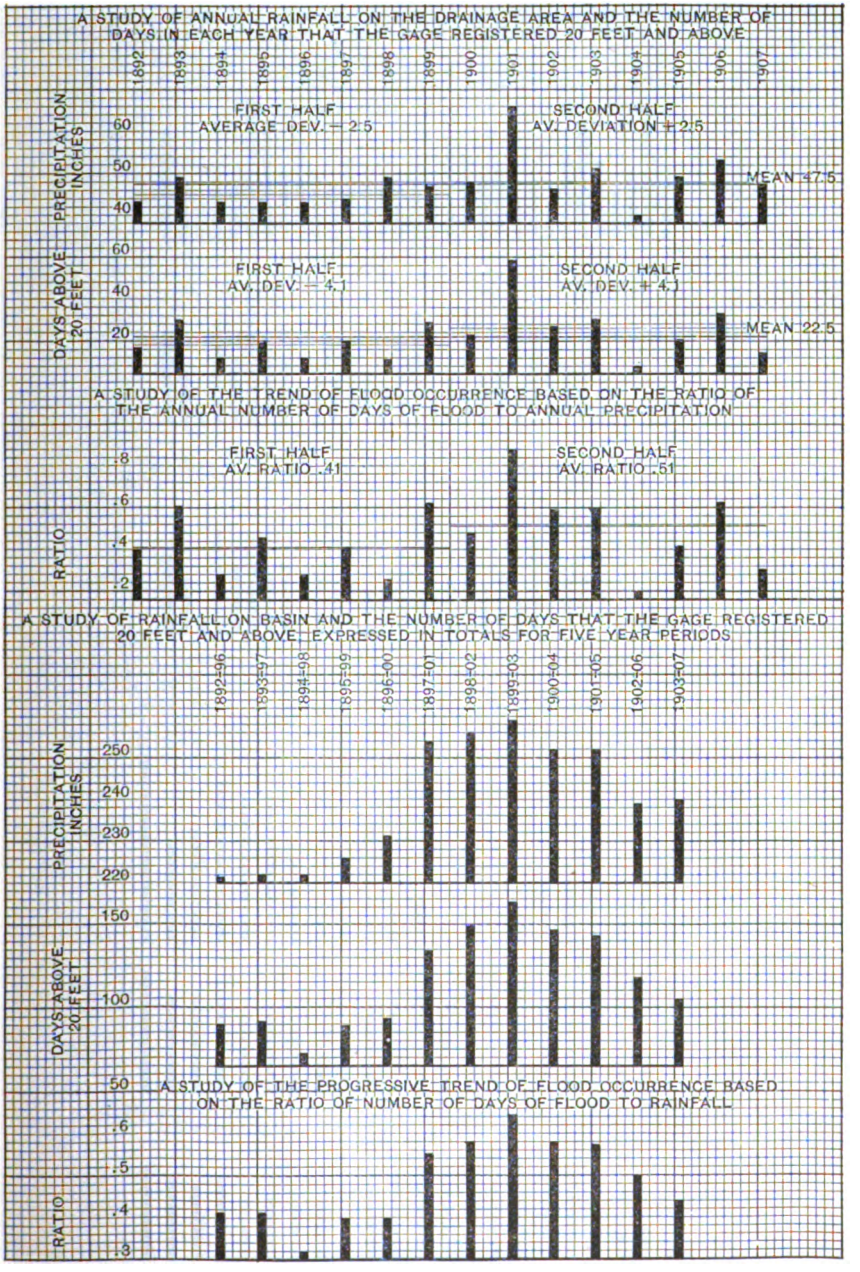
No. 5.

FLOODS ON WATEREE RIVER AT CAMDEN, S. C. 1892-1907.


A STUDY OF ANNUAL RAINFALL ON THE DRAINAGE AREA AND THE NUMBER OF DAYS IN EACH YEAR THAT THE GAGE REGISTERED 20 FEET AND ABOVE
1892 1893 1894 1895 1896 1897 1898 1899 1900 1901 1902 1903 1904 1905 1906 1907
PRECIPITATION INCHES
FIRST HALF AVERAGE DEV. = 2.5
SECOND HALF AV. DEVIATION = 2.5
MEAN 47.5
DAYS ABOVE 20 FEET
FIRST HALF AV. DEV. = 4.1
SECOND HALF AV. DEV. = 4.1
MEAN 22.5
A STUDY OF THE TREND OF FLOOD OCCURRENCE BASED ON THE RATIO OF THE ANNUAL NUMBER OF DAYS OF FLOOD TO ANNUAL PRECIPITATION
RATIO
FIRST HALF AV. RATIO .41
SECOND HALF AV. RATIO .51
A STUDY OF RAINFALL ON BASIN AND THE NUMBER OF DAYS THAT THE GAGE REGISTERED 20 FEET AND ABOVE, EXPRESSED IN TOTALS FOR FIVE YEAR PERIODS
1892-96 1893-97 1894-98 1895-99 1896-00 1897-01 1898-02 1899-03 1900-04 1901-05 1902-06 1903-07
PRECIPITATION INCHES
DAYS ABOVE 20 FEET
A STUDY OF THE PROGRESSIVE TREND OF FLOOD OCCURRENCE BASED ON THE RATIO OF NUMBER OF DAYS OF FLOOD TO RAINFALL
RATIO

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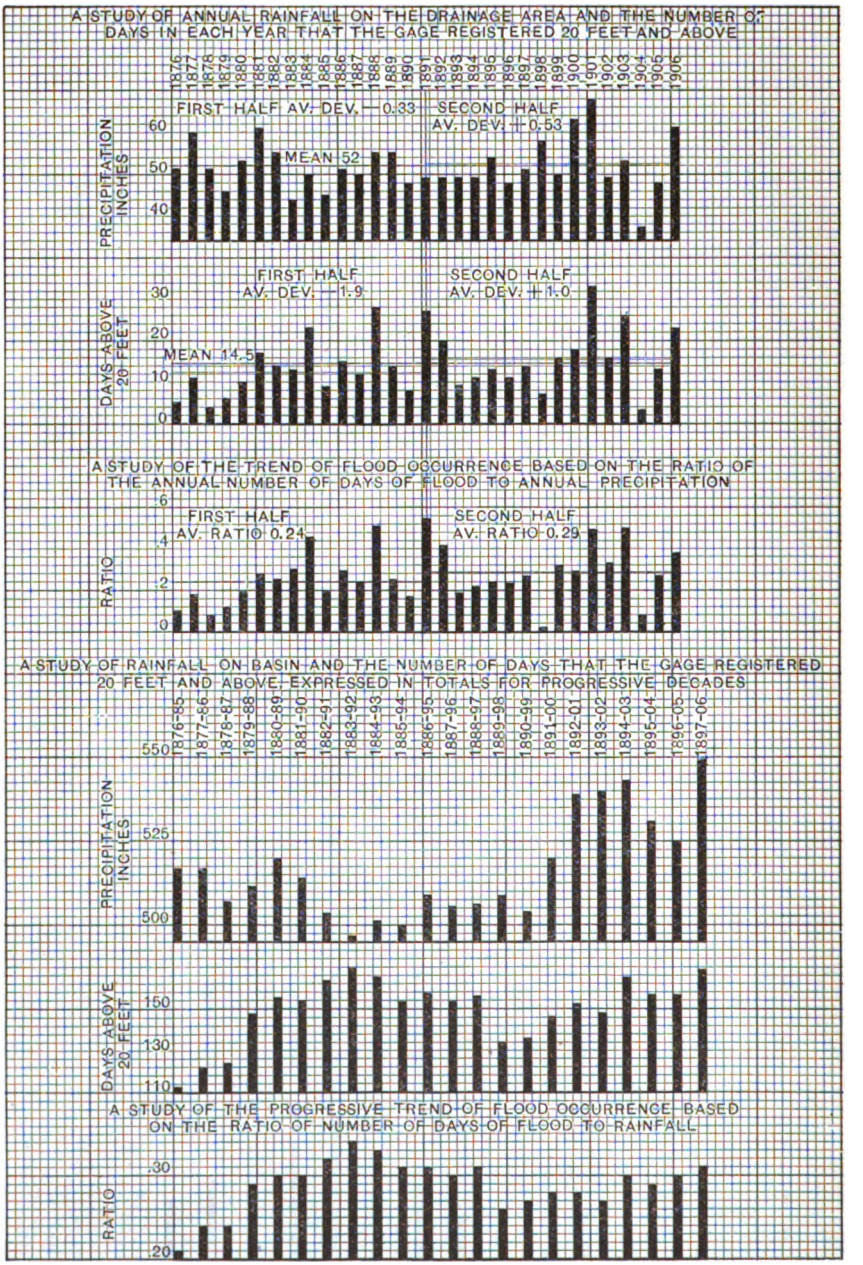
No. 6.

FLOODS ON SAVANNAH RIVER AT AUGUSTA, GA. 1876–1906.


A STUDY OF ANNUAL RAINFALL ON THE DRAINAGE AREA AND THE NUMBER OF DAYS IN EACH YEAR THAT THE GAGE REGISTERED 20 FEET AND ABOVE
PRECIPITATION INCHES
FIRST HALF AV. DEV. — 0.33
SECOND HALF AV. DEV. + 0.53
MEAN 52
DAYS ABOVE 20 FEET
FIRST HALF AV. DEV. — 1.9
SECOND HALF AV. DEV. + 1.0
MEAN 14.5
A STUDY OF THE TREND OF FLOOD OCCURRENCE BASED ON THE RATIO OF THE ANNUAL NUMBER OF DAYS OF FLOOD TO ANNUAL PRECIPITATION
RATIO
FIRST HALF AV. RATIO 0.24
SECOND HALF AV. RATIO 0.29
A STUDY OF RAINFALL ON BASIN AND THE NUMBER OF DAYS THAT THE GAGE REGISTERED 20 FEET AND ABOVE, EXPRESSED IN TOTALS FOR PROGRESSIVE DECADES
PRECIPITATION INCHES
DAYS ABOVE 20 FEET
A STUDY OF THE PROGRESSIVE TREND OF FLOOD OCCURRENCE BASED ON THE RATIO OF NUMBER OF DAYS OF FLOOD TO RAINFALL
RATIO

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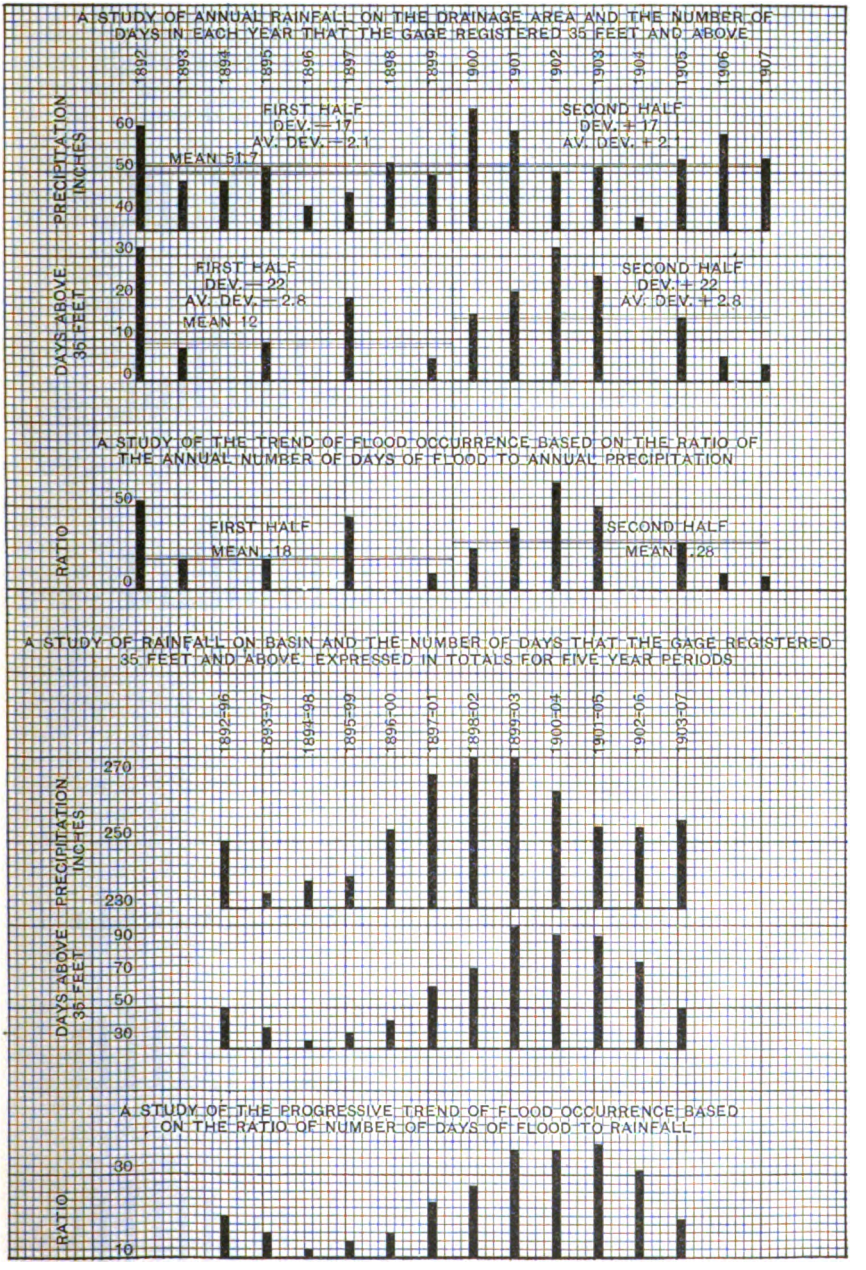
No. 7.

FLOODS ON ALABAMA RIVER AT SELMA, ALA. 1892-1907.



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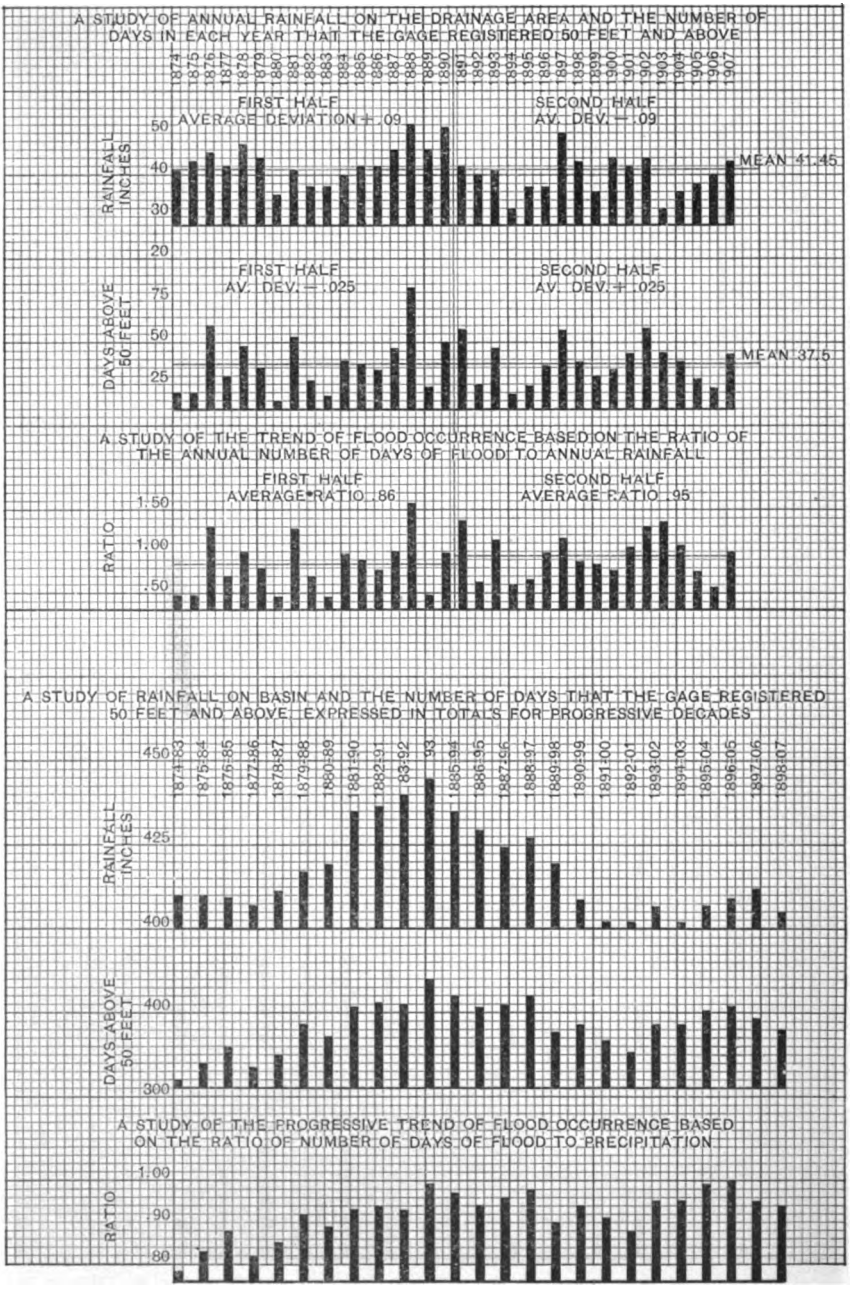
No. 8.

FLOODS ON CONNECTICUT RIVER AT HOLYOKE, MASS. 1874-1907.


A STUDY OF ANNUAL RAINFALL ON THE DRAINAGE AREA AND THE NUMBER OF DAYS IN EACH YEAR THAT THE GAGE REGISTERED 50 FEET AND ABOVE
1874 1875 1876 1877 1878 1879 1880 1881 1882 1883 1884 1885 1886 1887 1888 1889 1890 1891 1892 1893 1894 1895 1896 1897 1898 1899 1900 1901 1902 1903 1904 1905 1906 1907
FIRST HALF AVERAGE DEVIATION +.09
SECOND HALF AV. DEV. +.09
RAINFALL INCHES
50
40
30
20
MEAN 41.45
FIRST HALF AV. DEV. +.025
SECOND HALF AV. DEV. +.025
DAYS ABOVE 50 FEET
75
50
25
MEAN 37.5
A STUDY OF THE TREND OF FLOOD OCCURRENCE BASED ON THE RATIO OF THE ANNUAL NUMBER OF DAYS OF FLOOD TO ANNUAL RAINFALL
FIRST HALF AVERAGE RATIO .86
SECOND HALF AVERAGE RATIO .95
RATIO
1.50
1.00
.50
A STUDY OF RAINFALL ON BASIN AND THE NUMBER OF DAYS THAT THE GAGE REGISTERED 50 FEET AND ABOVE EXPRESSED IN TOTALS FOR PROGRESSIVE DECADES
1874-83 1875-84 1875-85 1877-86 1878-87 1879-88 1880-89 1881-90 1882-91 1883-92 93 1885-94 1886-95 1887-96 1888-97 1889-98 1890-99 1891-00 1892-01 1893-02 1894-03 1895-04 1896-05 1897-06 1898-07
RAINFALL INCHES
450
425
400
DAYS ABOVE 50 FEET
400
300
A STUDY OF THE PROGRESSIVE TREND OF FLOOD OCCURRENCE BASED ON THE RATIO OF NUMBER OF DAYS OF FLOOD TO PRECIPITATION
RATIO
1.00
.90
80

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As already stated, the rainfall, which is by far the most important of the climatic conditions, has been accounted for in these diagrams, and we have, therefore, remaining only the condition of the ground surfaces in the drainage areas and artificial agencies. For each of these rivers artificial agencies may be eliminated. Our general knowledge of conditions on the drainage areas gives assurance that there has been no reservoir installation of extent sufficient to modify in the slightest degree the normal conditions of flood discharge. This is also true with respect to artificial drainage.

Therefore we come down to the condition of the land surface, or, as above expressed, conditions of vegetation. We are aware that on all of these drainage areas there has been progressive cutting of timber and building of roads. The latter improvements, however, have not been of sufficient extent to modify in any appreciable degree the discharge. A computation of the actual road areas, including the paved streets, etc., will show conclusively that, in comparison with the total area under consideration, they are insignificant. The conditions of cultivated fields undoubtedly have a marked influence in modifying the rate of river discharge, and it is certain that some of the effects in these areas are due to this cause. The cultivation of fields has, however, improved markedly in recent years. The farmer has learned to a considerable degree that it is more profitable for him to cultivate his inclined fields by contour or terrace cultivation, and a cursory view of the areas represented in the accompanying diagrams will show that to a very large extent improved methods of cultivation have been put into effect.

Altogether, when the physical conditions on the drainage areas are summed up, the one great change that has been produced in the vegetative conditions is the reduction of forest area. On some of these drainage areas it has occurred by slow progression and on others more rapidly. It is certain that in some areas this forest cutting has caused barren conditions, because the land was of such a character that, after it was relieved of forest protection, it eroded easily and its productive portions were quickly swept into watercourses.

Summarily, therefore, it may be stated with confidence that the increase in flood tendency shown so unmistakably is due in by far the largest measure to the denudation of forest areas.

Diagrams 1 to 4, inclusive, are expressions of progressive changes in flood occurrence during the series of years indicated thereon. They are all drafted on a uniform basis, the first expression in each case being a record of the annual precipitation in inches; the second gives the number of days in each year that the gage at the point designated registered above a certain stage; the third is a combination of the first two and gives the relation of the number of days of flood to the precipitation. Thus, there is given in one expression the actual trend of flood occurrence in terms of precipitation. This form of expression eliminates one variable in the conditions governing flood occurrence, and the only remaining ones to be considered are vegetation and artificial agencies, as discussed in previous paragraphs.

The second series of diagrams on each sheet gives the same relations except that the amounts are united into progressive decades, or in one case into progressive five-year periods. This form of expression serves to neutralize the variability that occurs in the successive years

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and gives to the whole diagram a progressive trend which is more comprehensive and more easily interpreted than the statement of actual amounts. Thus, in sheet No. 1, the first progressive period covers the interval from 1885 to 1894, the second that from 1886 to 1895, and so on, each period representing ten years, and the total amount of rainfall and the total number of days of flood for each decade is expressed, rather than the average amount of these quantities.

In interpreting diagrams of this kind it should be emphasized that the amounts actually shown are not significant, save as they indicate the relative trend of the successive decades. In other words, the diagrams indicate direction, and should be so interpreted.

The data given on the above-mentioned sheets relate to the upper Ohio drainage area, and they show the relation of flood occurrence on the three principal tributaries thereof—the Allegheny, Youghiogheny, and Monongahela rivers—to flood occurrence on the Ohio at Wheeling. It will be seen that in each case there has been a marked increase in the number of days of floods, and the four diagrams can be consistently compared. At Wheeling during the period 1885 to 1907, inclusive, the ratio of flood occurrence to annual precipitation increased from 0.38 in the first half of the period to 0.48 in the second half, and this relation is shown more distinctly in the similar expression with the amounts given in totals for progressive decades. The gage records on the Allegheny at Freeport, Pa., show an increase in this ratio from 0.86 in the first half to 1.04 in the second half of the period 1874 to 1907, inclusive. The Monongahela record shows an increase of ratio during the period 1886 to 1907, inclusive, from 0.49 in the first half to 0.55 in the second half, while a still greater divergence is noted on the Youghiogheny, the ratio for the period 1875 to 1906, inclusive, increasing from 0.35 in the first half to 0.47 in the second half.

Altogether, these diagrams are extremely significant in showing the progressive increase in flood occurrence on a drainage area the deforestation of which has been constant and rapid for the past thirty years. It began first on the Allegheny and the results are apparent in the diagrams. Subsequently, timber cutting began on the Monongahela and Youghiogheny areas and is occurring at the present time.

Similar results are shown on sheets Nos. 5 to 7, inclusive, which give the same data for Wateree River above Camden, S. C., the Savannah above Augusta, Ga., and the Alabama above Selma, Ala.

Sheet No. 8 is a record of flood duration on Connecticut River at Holyoke, Mass. This river basin has been subject to continuous deforestation for a long period. Recent testimony shows that for the last twenty years from 50,000,000 to 80,000,000 feet B. M. of timber have been released over the dam at Turners Falls annually. Records of private logging are not available, but it is known that the deforestation of the drainage area commenced some time previous to this period.

There is one point of objection that may reasonably be taken to the diagrams above discussed. It is that they draw comparison between annual precipitation and the number of days of flood. A better comparison would be one between the number and depth of flood-producing rains and the number of flood days. Such a comparison has been

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made on the Tennessee basin above Chattanooga. No other basins are here dealt with in this way because of the enormous amount of labor involved.

In addition to proving beyond controversy the increase in floods due to deforestation, the record is of interest because it shows how futile and misleading is the attempt to derive conclusions from flood records without taking into account records of precipitation. Inspection of the Chattanooga flood record shows a decided decrease in the number and duration of floods during the period of record. If this were taken alone, it would controvert the forest-control idea. A comparison of the precipitation records on the drainage area, however, assures us that the rainfall has decreased, even to a greater relative extent than the floods. The final result is that the flood tendencies have increased.

The results for the Tennessee basin cover 24 years, from 1884 to 1907, inclusive. Although the records of gage height extend further back than the earlier date, the number of rainfall stations maintained on the basin previous thereto is not sufficient to render safe any conclusions with reference to precipitation. It is appreciated that a given depth of rainfall precipitated during the winter months will generally produce a greater run-off than the same depth would produce in August or September. Therefore an effort has been made to eliminate this source of error. Summing up the flood-producing rains for the 24-year period it is found that the total is 335, of which 313 occurred from December to May, inclusive, and the remaining 22 during the other portion of the year. It is apparent that the number of such rains from June to November is not sufficient to afford a basis of comparison. Therefore only the December to May floods will be considered. In making this comparison the ideal condition would be to compare the rainfalls and floods during identical conditions of climate, but such a refinement is impossible. On the other hand, the multiplication of data afforded by the large number of flood-producing storms in the December to May periods warrants the conclusion that the varying climatic conditions in this period are compensated, and the final conclusions drawn from the result must be worthy of confidence. On dividing the period covered by these 313 floods equally, two consecutive 12-year periods are afforded, which give a basis of comparison. The floods in the later period, resulting from a given depth of storm precipitation, are clearly shown to be more severe than in the earlier period. The method of presentation further makes it possible to compute the increase in flood tendency due to deforestation in the Tennessee.

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The relation between storms and floods in the Tennessee basin during the periods December–May, inclusive, 1884–1895 and 1896–1907.

Period.	Storms in inches precipitated.											
	1 to 1.5.		1.5 to 2.		2 to 2.5.		2.5 to 3.		3 to 3.5.		3.5 to 4.	
	Storms.	Days of flood.	Storms.	Days of flood.	Storms.	Days of flood.	Storms.	Days of flood.	Storms.	Days of flood.	Storms.	Days of flood.
1884–1895	7	5	12	6	6	15	5	9	5	13	6	30
1896–1907	8	3	11	10	9	23	11	30	4	13	1	6

Period.	Storms in inches precipitated.											
	4 to 4.5.		4.5 to 5.		5 to 5.5.		6 to 6.5.		7 to 7.5.		8 to 8.5.	
	Storms.	Days of flood.	Storms.	Days of flood.	Storms.	Days of flood.	Storms.	Days of flood.	Storms.	Days of flood.	Storms.	Days of flood.
1884–1895	1	6	2	17	2	18	.....	.....	2	28	.....	.....
1896–1907	1	8	3	20	.....	.....	1	11	.....	.....	1	17

If we now divide the number of flood days by the number of storms, the result will be the number of days per storm. Applying this to each of the series in the above table, the following result is reached:

Days of flood per storm.

Period.	Storms in inches precipitated.							
	1 to 1.5.	1.5 to 2.	2 to 2.5.	2.5 to 3.	3 to 3.5.	3.5 to 4.	4 to 4.5.	4.5 to 5.
1884–1895	0.7	0.5	2.5	1.8	2.6	5	6	8.1
1896–1907	.4	.9	2.6	2.7	3.2	6	8	6.7
Percentage increase	−43	80	4	50	22	20	33	−17

The algebraic sum of the above percentages is 149.00 and the average is 18.75, which sums up the effect of deforestation on run-off from 1884 to 1907, inclusive.

FLOOD DAMAGES.

A complete census of flood damages for any year or series of years has never been attempted. Therefore, it will be impossible to present any figures for which precision may be claimed. The damages for particular floods in certain areas have from time to time and for one or another purpose been assembled and, in a few places, examinations have been made with great care by commissions and boards especially qualified for such work. The results of such examinations may be taken to form a basis for an estimate; but, for the present purpose, a better basis has been made available. During

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the present year the Geological Survey has made inquiry of all the railroads in the United States concerning flood losses during the period January 1, 1900, to August, 1908. The railroads were selected for this purpose because it is well known that they are, by reason of their location and extent, subject to far greater physical damage than any other single interest, and it was believed that from the figures so procured a fairly representative basis of estimate might be obtained. From previous studies of this matter it appeared that the railroad losses resulting from floods amount to about 10 per cent of the total physical loss arising therefrom, excluding, of course, the largest single item of loss, which is the depreciation of realty values arising from flood menace. The figures here presented will therefore exclude all consideration of this kind of loss.

The proportion of 10 per cent was arrived at from three points of view:

First. It has been the observation of the writer that, as a rule, the reported losses to railroads from floods have amounted to about this proportion.

Second. The actual investigations of flood losses, made by appraisal boards, and individual property returns covering fairly wide areas have approximated this proportion. Undoubtedly the most complete and comprehensive investigation of this kind was carried on by the northern New Jersey flood commission in 1903, after the great flood that arose in October of that year along Passaic River. The region comprehended in this investigation may be considered a typical one. It comprised the usual proportion of farm lands, city areas, highway bridges, railroad property, etc., and the proportion of railroad loss there was almost exactly 10 per cent of the total.

Third. One-tenth of the wealth of the United States consists of railroad property. This proportion was therefore used in the following estimates.

During each of the periods above named the returns from the railroads involved a varying percentage of the total mileage of the country. The mileage involved in each yearly estimate has been expressed as a percentage of the total mileage for that year, as given in the reports of the Interstate Commerce Commission. The several amounts were increased from the percentage that they represented to 100 per cent, to cover the entire mileage of the country. Inspection of the returns showed that this was a fair and reasonable method, because the reports were well distributed and represented a true proportion of that which might be expected to be the damage on the total mileage. This figure was then considered as 10 per cent of the total damage for the whole country and increased accordingly. The results are given in the following table:

Year.	Damage reported.	Percentage of total mileage reported.	Total railroad damage.	Estimated total damage.
1900	$666,253	14.6	$4,567,500	$45,675,000
1901	958,740	21.1	4,543,800	45,438,000
1902	1,225,468	22.2	5,520,100	55,201,000
1903	2,654,192	27.3	9,722,009	97,220,000
1904	2,476,724	31.3	7,884,100	78,841,000
1905	3,286,324	33.3	9,858,972	98,589,720
1906	2,727,511	37.3	7,312,400	73,124,000
1907	4,023,106	39.1	11,823,800	118,238,000
1908	6,517,577	27.4	23,786,000	237,860,000

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STORAGE OF FLOOD WATERS.

In the northeastern portion of the country there has been a large installation of reservoirs and a consequent saving of enormous amounts of flood water. The numerous lakes in that part of the United States, irrespective of those that have been developed artificially, have a beneficial effect. It is probable that 10 per cent of the flood waters that originate in New York and New England are saved by storage in artificial reservoirs, lakes, and ponds. In Minnesota, at the head of upper Mississippi River, practically the entire flood drainage from an extensive area is conserved. In the arid West there has been an extensive installation of reservoirs, some of which conserve practically all the flood waters on their respective basins. Considering the country as a whole, however, it is doubtful if more than 1 per cent of the flood water is saved.

The storage of floods is effected by forests and similar surface vegetation and by artificial reservoirs. The amount stored by forests is and probably will for a long time to come be indeterminate, since the forest is merely an agent in assisting the ground to absorb the water. The storage is therefore essentially ground storage and the ability of the forest to enhance this is dependent absolutely on the character of the soil beneath the forest. Therefore, to fully answer the question, "To what extent could flood waters be stored by forests?" it would be necessary to consider minutely the absorption properties of the various kinds of land surface in the United States. It will be possible at some future time to give an approximate and exceedingly useful reply to this question; but before that time arrives we must have more long-term gage records on our rivers. The diagrams presented with this paper (sheets Nos. 1 to 8, inclusive) constitute as useful records as there are extant in the country, and a short consideration of them will plainly reveal the fact that, while they are exceedingly useful in indicating the trend of flood duration and frequency, they do not yet yield sufficient information to give even the widest approximation of the amount of water or the proportion of run-off that can be conserved.

The question is therefore one for the future, and our stream investigations should be carried on with this as one of the purposes in view.

The extent to which flood waters could be stored by reservoirs depends on the available reservoir capacity in the several river basins. As a rule, the more diversified the character of these basins, especially in contour, the greater facilities they afford for reservoir storage.

There is a great portion of the Mississippi Valley in which floods are not subject to correction under the reservoir plan. This is also true of certain coastal-plain streams like the Brazos and Colorado. It is probable that the streams draining one-third of the area of the United States must forever be subject to floods, and the only treatment that now appears feasible for these streams is the construction of levee systems. For the remaining two-thirds of the United States, investigations so far made indicate that from 55 to 60 per cent of the flood waters can be saved by the utilization of maximum storage capacity. Although the cost of such construction would be enormous in the aggregate, it is apparent that the saving that would accrue

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from relief from flood damages alone would soon return the entire investment. A glance at the estimated flood damages in the United States, page 109, shows the possibilities. In this connection it should be stated that in by far the larger proportion of the basins a saving of 55 to 60 per cent of the flood waters would insure practically entire relief from flood damages. It is not necessary to prevent floods absolutely; or, in other words, it is not necessary to secure uniformity of flow in any river in order to secure relief from flood damages. The construction of the reservoirs necessary to prevent floods would, under proper management, involve an increase in the water-power possibilities of the United States equal to about 60,000,000 horse-power. In the arid West the construction of reservoirs for flood prevention would provide water sufficient for the reclamation of many million acres of now worthless land. All of this, together with the assistance that such reservoirs would lend to navigation, constitutes the saving that would accrue from their construction. We are unable at the present time even to approximate the total figure, and therefore it must be summed up in the term "vast."

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RELATION OF SURFACE CONDITIONS TO STREAM FLOW.

By WM. L. HALL and HU MAXWELL.
U. S. Forest Service.

Popular opinion for years has been that floods are increasing in frequency and duration in many rivers of the United States. Until within a year, however, there had been no careful examination of records to see whether or not the popular opinion is based upon fact. The scientific bureaus of the Government which are directly interested in the matter had assumed that records had not been kept long enough on any river to show a change in the conditions of flow. As late as September, 1908, Col. H. M. Chittenden, of the Engineer Corps of the Army, in a paper presented before the American Society of Civil Engineers, said:

> The constantly reiterated statement that floods are increasing in frequency and intensity, as compared with former times, has nothing to support it. There are, it is true, periods when floods are more frequent than at others, and hasty conclusions are always drawn at such times, but taking the records year after year for considerable periods no change worth considering is discoverable.

About a year ago it was thought worth while to look into the records to see whether any changes were discernible. The results were surprising. It was found that in many of the streams which take their rise in the Appalachian Mountains there has been a steady increase in the number and duration of floods during the past twenty or thirty years.

Following this discovery, a very general study was made of the change which has come about in the flow of a number of important rivers during the time for which records have been kept. Both the Geological Survey and the Forest Service have presented data on this subject during the year, and the results of both warrant the statement that unmistakably floods are steadily on the increase in some of our most important rivers.[a] Particularly is this true of the rivers which rise in the eastern mountains. The increases seem to be greater on those watersheds where the condition of the surface has been the most changed. They are greatest in such streams as the Ohio, Cumberland, Wateree, and Santee, where the most forest has been destroyed, and least on the streams where forest conditions have been least changed.

It is true that in certain rivers an opposite tendency is to be seen. Floods have decreased and low waters have markedly improved. But a full inquiry into the conditions on these rivers also, as will be shown, seems to prove the rule that there is the closest kind of relationship between the surface conditions of a watershed and the flow of water through the stream which drains it.

The following table gives records regarding the flow of 10 important rivers of the United States on which careful records have been kept for periods ranging from sixteen to thirty-four years:

[a] Floods in the United States, by M. O. Leighton, Chief Hydrographer, U. S. Geological Survey. Paper prepared for National Conservation Commission.

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Flood and low-water records for 10 important rivers.

CLASS I.—FLOODS INCREASED.

Name of stream.	Point of measurement.	Area of basin.	High-water stages taken in this table.	Low-water stages taken in this table.	First and second periods of record.		High-water data.						Low-water data.						Precipitation.		
					Years.	Duration.	Number of floods.	Days of floods.	Average times per year of floods.	Average days per year of floods.	Times of last period compared with first.	Days of last period compared with first.	Number of low stages.	Days of low stages.	Average times per year of low stages.	Average days per year of low stages.	Times of last period compared with first.	Days of last period compared with first.	Number of stations.	Mean (inches).	Mean annual increase or decrease (inches).
		Sq. mi.	*Ft.*	*Ft.*		*Yrs.*					*Per ct.*	*Per ct.*					*Per ct.*	*Per ct.*			
Potomac	Harpers Ferry, Va.	9,363	12	3	1890–1898	9	19	33	2.11	3.55	a36.80	a72.70	54	1,351	6.00	150.00	a40.7	a25.3	5	36.81	+.13
					1899–1907	9	26	57	2.77	6.33			76	1,693	8.44	188.00			5	37.97	
Monongahela	Lock 4, Pennsylvania	5,430	20	7	1886–1896	11	30	55	2.73	5.09	a73.00	a82.00	66	912	6.00	83.00	a36.33	a7.33	6	42.25	−.08
					1897–1907	11	52	100	4.73	9.09			90	979	8.17	89.00			6	41.35	
Ohio	Wheeling, W. Va.	23,820	22	5	1882–1894	13	46	143	3.54	11.00	a28.25	a31.50	79	1,333	6.08	112.50	a39.00	a20.75	11	41.74	−.14
					1895–1907	13	59	188	4.54	14.40			110	1,609	8.46	123.70			11	39.90	
Cumberland	Burnside, Ky.	3,739	25	3	1890–1898	9	32	89	3.55	9.90	a34.40	a14.60	61	1,261	6.77	138.00	a6.50	a27.00	3	46.27	−.54
					1899–1907	9	43	102	4.77	11.33			65	1,576	7.17	175.00			3	41.42	
Wateree	Camden, S. C.	5,135	20	6	1892–1899	8	46	147	5.75	18.37	a35.00	a22.00	115	1,164	14.37	145.50	b44.30	b56.40	3	45.46	+.25
					1900–1907	8	70	187	7.75	23.50			64	508	8.00	63.50			3	47.48	
Savannah	Augusta, Ga.	7,300	20	6	1890–1898	9	47	116	5.22	12.77	a23.40	a46.50	70	566	7.70	63.00	b41.00	b48.00	3	48.12	−.17
					1899–1907	9	58	170	6.44	17.77			41	292	3.56	32.00			3	46.58	
Tennessee	Chattanooga, Tenn.	21,418	24	2	1874–1890	17	32	173	1.88	10.18	a3.13	b20.80	71	902	4.17	53.00	b22.53	a8.86	5	53.17	−.37
					1891–1907	17	33	137	1.94	8.06			55	982	3.24	57.70			5	46.83	
Allegheny	Freeport, Pa.	9,220	16	2	1874–1890	17	39	92	2.29	5.41	a35.90	a42.40	99	1,747	5.82	102.70	b8.10	a35.00	3	41.65	−.32
					1891–1907	17	53	131	3.12	7.70			91	1,136	5.35	66.80			3	36.17	

CLASS II.—FLOODS DECREASED.

Wabash	Mount Carmel, Ill.	26,300	15	3	1890–1898	9	21	351	2.33	39.00	b9.50	b20.50	38	1,365	4.22	152.00	b15.75	b15.00	5	39.54	−.40
					1899–1907	9	19	279	2.11	31.00			44	1,160	4.93	129.00			5	35.99	
Red	Arthur City, Tex.	40,200	20	4	1892–1899	8	19	87	2.37	10.87	b16.00	b30.00	49	826	6.12	103.25	b83.60	b74.80	5	31.80	−.24
					1900–1907	8	16	60	2.00	7.50			8	208	1.00	26.00			5	29.86	

a Increase. b Decrease.

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THE TENDENCY IS TOWARD INCREASED FLOODS.

If the period during which the records have been taken on each of these streams be divided into two equal parts and a comparison be made of flood conditions for those parts, we find that 8 of the 10 rivers show greater floods in the last half than in the first half. The 8 rivers which show increased floods are the Potomac, at Harpers Ferry, W. Va.; the Monongahela, at Lock 4, Pennsylvania; the Ohio, at Wheeling, W. Va.; the Cumberland, at Burnside, Ky.; the Wateree, at Camden, S. C.; the Savannah, at Augusta, Ga.; the Allegheny, at Freeport, Pa.; and the Tennessee, at Chattanooga, Tenn. All of these streams, it will be noted, have their source waters in the Appalachian Mountains.

On the Potomac River, for which measurements are given for eighteen years, the number of floods during the first half of the period was 19; during the second half, 26; while the number of days of flood in the first half was 33, and in the second half, 57.

On the Monongahela River measurements are given for twenty-two years. During the first half of the period there were 30 floods; during the second half, 52. The number of days of flood during the first half of the period was 55; during the second half, 100.

On the Ohio River measurements are given for twenty-six years. During the first half of the period there were 46 floods; during the second half, 59. The number of days of flood during the first half was 143; during the second half, 188.

On the Cumberland River measurements were given for eighteen years. During the first half of the period there were 32 floods; during the second half, 43. The number of days of flood during the first half was 89; during the second half, 102.

On the Wateree River measurements have gone on for sixteen years. In the first half of the period the number of floods was 46; in the second half, 70. The number of days of flood in the first half of the period was 147; in the last half, 187.

On the Savannah River measurements have continued for eighteen years. During the first half of the period the number of floods was 47; during the second half, 58. The number of days of flood during the first period was 116; during the second half, 170.

On the Allegheny River measurements are given for thirty-four years. During the first half of the period there were 39 floods; during the second half, 53. The number of days of flood during the first half was 92; during the second half, 131.

On the Tennessee River measurements have been taken for thirty-four years. During the first half of the period there were 32 floods; during the second half, 33. The number of days of flood during the first half was 173; during the second half (in this case there was a falling-off), 137.

Mr. M. O. Leighton, chief hydrographer of the United States Geological Survey, has during the past year made an elaborate study of the floods in the Tennessee River.[a] In this study Mr. Leighton has isolated so far as possible the days of rain storm of sufficient magnitude to produce floods, and on this basis has made a comparison of

[a] Floods in the United States, by M. O. Leighton, chief hydrographer, U. S. Geological Survey.

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the floods of the two halves of the period. Although the number of days of flood was less during the last half of the period than during the first half, Mr. Leighton shows that the precipitation decreased in an even greater degree. The results of this close analysis show that the diminution of the precipitation has been more than sufficient to account for the diminution of the floods. The natural result is that in proportion to the rainfall, floods have increased, the percentage of increase being 18.75 in the last half of the period as compared with the first half. This study is undoubtedly the most complete and authoritative that has ever been made of any American river, and it seems conclusive.

The low-water stages of a river are never a safe criterion on which to judge its real condition. A slight change in the bed of a stream may considerably affect the low stage at the point where the measurements are taken, though the real condition of the stream may not be changed in the least. In the same way a stream may actually raise its bed by silting, and thus the low-water stage may be increased while the actual condition is worse than at first. A study of the low-water data of the above table shows that intensified low-water conditions as signified by the measurements do not correspond in all cases with intensified flood conditions. Of the eight streams above referred to, four show apparently intensified and four apparently ameliorated low-water conditions. But for the reasons just stated, these records can not be depended upon as having any real significance in showing the actual flow.

The constant increase in the frequency and duration of floods in these streams appears not to be due to change in precipitation. In two cases there has been a slight increase in precipitation. These are on the Potomac watershed, where, as the table shows, there has been on the average 1.16 inches more rain in the second half than in the first half of the period. On the Wateree there was an increase of 2.02. On all of the other watersheds there has been a decrease ranging from 0.90 of an inch on the Monongahela to 6.34 inches on the Tennessee. It is thus clear that while floods have greatly increased in these streams the tendency has been toward decreased precipitation.

While the record is given for only eight streams which show increased floods, it must not be understood that these are the only streams which show this tendency; rather, they are examples—particularly they are examples of streams having their source in the Appalachian Mountains. They have been given because their records are more complete and longer than those for other streams. The records of most other streams of the region, so far as they are sufficient to show a tendency, indicate the same progressive change toward increased floods. For example, this is true of the Alabama River, of the Connecticut, of the Muskingum, and of the Congaree.

WHAT HAS CAUSED INCREASED FLOOD CONDITIONS?

Since it is apparent from the records that flood conditions have greatly intensified in many streams during the past two or three decades, it is important to consider the possible causes. Several factors are known to have an important influence upon stream flow. Chief among these are climate, topography, geology, natural or artificial reservoirs, soil, and ground cover. Climate must be understood

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as embracing precipitation and evaporation, with whatever influences them—notably, wind, humidity, temperature, and altitude. It is best to consider precipitation and evaporation separately, for they act in opposite directions and produce opposite effects.

PRECIPITATION.

It is, of course, apparent that precipitation must modify stream flow in a vital way, because no water can flow through the streams that does not first come down from the clouds. The amount of precipitation varies greatly from year to year. The amount for one year may be twice as great as for another in the same place, and at one point it may greatly exceed or fall short of that occurring a few miles away. While varying in a marked degree for short periods, precipitation becomes much more nearly constant through a long period.

If the precipitation had correspondingly increased over the Appalachian Mountain region, then it could be said that the greater and more frequent floods are due to that. But the figures which are given show that on only two of the eight watersheds mentioned in the table has there been any increase, and there by small amounts, while in the other six there has been a decrease, which in the case of one stream, the Tennessee, amounts to an average of 6 inches. The real tendency of the precipitation over these basins would therefore be to decrease flood conditions. Consequently, we must conclude that the increased flood conditions are in no degree due to precipitation.

EVAPORATION.

Taking the United States as a whole, less than half of the precipitation is said to pass through the rivers to the sea; the other part after a longer or shorter period, and after serving one purpose or another in nature's economy, goes back to the air through evaporation, except that portion which flows through underground courses to the sea.

Evaporation is fundamentally influenced by temperature, air pressure, wind, and humidity, and affects in a vital way both the regularity and amount of run-off of the streams. The Connecticut and Wateree rivers have about the same average annual precipitation—45 inches per year. Of this amount the run-off from the Connecticut watershed is 29 inches; from the Wateree watershed it is less than 18 inches. The difference is due to increased evaporation on the Wateree, where the temperature averages much higher. It is during the prolonged heated periods, which are often dry periods, that evaporation has greatest influence. It undoubtedly affects as much as any other factor the low-water stages of the streams, yet by its very nature it can not much influence floods, because they rise quickly and are never of many days' duration. There is not time for much water to evaporate. Hence we can put aside this climatic influence just as in this case we have put aside precipitation. We must look elsewhere for the cause.

TEMPERATURE.

Temperature, while influencing stream flow indirectly, through evaporation, also influences it directly. For example the upper watershed of the Monongahela River, in West Virginia, may be considered:

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It is February, and there have been several weeks of cold weather; the ground, which is bare of snow, is frozen solid. There comes a heavy fall of snow, or perhaps several, bringing the snow cover to a depth of 12 to 18 inches. Within a few days the weather moderates and a prolonged rainy period follows. The first rain is caught by the snow and little escapes. But as it continues to come, it melts the snow so that the water from the snowfall and the rainfall is concentrated upon the surface at one time. If the ground were not frozen, much of it could be absorbed and distributed downward, but in the case we have assumed the earth is frozen solid, so that no water, or at least but little, can be absorbed. The whole volume is liberated on the surface and races away from the smaller streams to the larger, and at last, gathering in immense quantity, it overtaxes the channel of the main river and inundates the entire valley. It is this condition of rain, snow, and temperature operating together which brings about some of the greatest floods. A flood resulting from such a cause is not likely to occur more than once a year in any stream, and several years may pass without flood on a given watershed from this combination of causes. It can not be said that floods from this cause show any progressive change, and consequently we can not ascribe to this cause the increased flood conditions in the rivers now under consideration.

TOPOGRAPHY AND GEOLOGY.

A region's topography largely influences its run-off. Steep slopes and sharp ridges shed water quickly. A flat surface causes it to flow away more slowly.

Likewise, geology has a great deal to do with the drainage of any region. When rain has fallen and has passed through the soil cover and the soil, it comes in contact with the rocks which lie beneath. In obedience to gravity it will penetrate as deeply as possible. Considering the depth to which it can go and the quantity in which it can be stored, the earth forms a great storage reservoir which tends on most watersheds to have a strong influence toward steadiness in the flow of streams. While topography and geology are important factors in considering the amount and character of run-off, when one stream is compared with another, they are of no consequence when one is considering the condition in the same stream during two different periods, because they are subject to no appreciable variation. Both the topography and the geology of any given stream may be said to be constant, and so are not of importance in considering what has caused a changed condition of flow in any particular stream.

NATURAL AND ARTIFICIAL RESERVOIRS.

Some streams have on their watersheds great lakes which gather and hold immense volumes of water. A good example is the Merrimac River. On one of its important tributaries is that fine body of water, Lake Winnepesaukee; on another is Squam Lake, and, in addition, there are many smaller ones. Every natural reservoir of this kind tends to equalize the flow of the stream it feeds, because when its level is rising it is gathering in storage to pay out gradually the water which would otherwise run off at once. Moreover, on

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many of the lakes, especially on those in New England, dams have been built at the outlets. By this means the water of the whole surface has been increased a number of feet in depth. In dry times when it is needed this water is emptied out. A large portion is thus taken off of the crest of each flood and added to low waters. Then, too, men may construct reservoirs where there were none before. It is considered feasible in some streams to construct such extensive reservoir systems as to store a large part of the flood waters. If this can be done, the flow of the streams can be made for all practical purposes even throughout the year.

If at the headwaters of the rivers under consideration in this paper there had been great lakes or swamps which had been drained during the period under consideration, it might well be said that the influence of that action would be sufficient to cause a difference in the run-off of the streams. But, except in the case of the Wabash, there have been no changes of this character. There are on these streams no important natural lakes, and no reservoirs of great extent have been developed. Consequently, this factor also is insignificant.

SOIL.

Though the topography and geology of a watershed change too slowly to be readily observed, there are other factors in which changes may be rapid, radical, and of great importance. One such factor is soil. The soil, when considered as a factor in controlling run-off, is a complicated and delicate apparatus. It works admirably when in good condition, but it is easily deranged and is liable to severe and fundamental injury, by which its action on storm water may be lessened or almost entirely destroyed. Mistreatment frequently produces results of a serious nature in the drainage of a watershed.

The mineral soil is composed of disintegrating rock that has broken down by the slow process of weathering. Deep mineral soils, if they have not accumulated from transported materials, represent a long period of rest, during which the surface has been free from erosion, while the disintegrating rock beneath has added little by little to the depth. Upon the mineral base, and more or less mixed with it, is the humus, which owes its existence to organic matter mostly vegetable, which has decayed and added the accumulated remnants to the mineral soil. Humus vastly increases a soil's capacity to absorb and store water.

The important work which soil performs in regulating the run-off for a region is easily understood. If the soil is present in sufficient quantity and good condition; that is, is porous and well supplied with humus, it readily absorbs storm water at the surface and passes it on downward through the underlying rocks and strata. Although these rocks themselves change but little, their storage of water is regulated by the soil and varies with its changes. If the soil is hardened or removed, the amount of water which can be taken in is correspondingly reduced, and the amount which is thrown off over the surface into the streams correspondingly increased. A watershed without soil or with a soil which does not readily perform its normal functions, results in erratic streams, which are usually agents of destruc-

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tion rather than of use. The consideration of the flow of any stream should therefore take particular note of the soil and of the changes in its capacity for water storage.

GROUND COVER.

Scarcely separable from the soil itself is another factor of equal or greater importance in the disposition of water. This is the ground cover, or, to speak of it more particularly, the condition of the surface of the ground; that is, whether it is barren rock or clay, pasture land, cultivated land, or forest.

The condition of the surface does not influence very much, so far as known, the amount of water which falls. It is claimed by some that the precipitation is greater in the forest than on unforested land, and the figures given in the table at the beginning of this paper seem to indicate a tendency toward lessened precipitation on those watersheds which will presently be shown as having a decreased forest area. However, it is not intended at present to lay any stress upon that point. If the influence of the various factors which affect stream flow have been correctly stated, none of them is sufficient to have caused the increased floods. The natural conclusion is that the increase must be due to changes in the ground cover, or to the ground cover in conjunction with changes in the soil. Is the influence of the ground cover and of the soil sufficient to have caused the results?

It is generally agreed by those who have studied the subject most thoroughly that the forest offers the best conditions for absorption and underground storage. Next to the forest comes well-cultivated farm land; then meadow and pasture land; while the worst conditions of all are to be found on barren surfaces of stone, clay, or gravel, which because of infertility are unable to support growth of any kind.

The reasons why the forest offers the best conditions for absorption and ground storage are several. It does so, in the first place, because the foliage of the trees forms a storage place from which water drips slowly to the ground for a considerable length of time after each rain; because the complex layer of brush, leaves, weeds, mosses, and vines, all in a more or less advanced stage of decay, becomes filled with moisture with each heavy rain and holds it for a considerable time; because, also, the surplus water so stored continues to be absorbed by the upper humus-filled layers of earth; because, further, the temperature is lower and the air more humid in the forest than in the open; finally, because the snow lies there much longer. To these reasons must be added the mechanical power of the roots to go deep into the soil and break up the rocks, thus forming channels for the ready entrance of water into the earth.

On a level or slightly inclined surface a well-tilled soil may be as effective in absorbing and holding water as a forest soil. Where the slope exceeds 10 per cent, cultivation does not long go on before erosion sets in, and erosion if unchecked will remove the soil and gully the surface until all fertility has gone and all protective power is lost. Agriculture under right conditions may be an effective means of stream protection; under wrong conditions it may be the greatest menace to the even flow and usefulness of the streams.

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THE PRINCIPAL CAUSES OF INCREASED FLOODS.

Undoubtedly it is the clearing away of the forest on the mountainous watersheds of the streams which have been described that has caused the great increase in frequency and duration of floods.

It is a known fact that the forests on these several watersheds have been cut away with great rapidity during the past thirty years. European conditions probably offer no parallel to the rate at which these watersheds have been cleared to make way for the rapid advance of agriculture and to supply the great manufacturing industries with the wood which they require. Forest lands, which offer the best possible conditions for soil absorption and underground storage, those great regulators of stream flow, have been changed to poorly tilled agricultural lands, which are not so good. Then these agricultural lands after a few years have been exhausted and their soil eroded into deep gullies. Finally, many of them have been turned into pasture or even entirely abandoned because they reached a condition where they could not support even a growth of grass and weeds. The best condition has been changed to the very worst condition.

Again, repeated burning of forest lands has tended to reduce the thickness and value of the ground cover and to lessen the power of the soil to absorb and to store water. The extent of damage from fire, so far as water storage is concerned, is generally vastly underestimated. A forest fire strikes both above and below the surface. It injures or kills the trees, destroys the undergrowth and brush, and consumes the great forest sponge—the ground cover and the humus. The extent of the injury is, of course, not always the same. It is sometimes slight; sometimes very great. Repeated fires tend to every kind of injury that can possibly be inflicted upon a forest soil, completely destroying the cover down to the mineral substances, and thus rendering it defenseless against the attacks of erosion. When that stage is reached, it may be depended upon that the run-off of the watershed has been profoundly affected, and the regimen of the stream materially changed. The fact that forest fires have repeatedly swept over the watersheds of the streams under consideration makes it easy to believe that this factor combined with the clearing away of the forest for agricultural purposes has been the chief cause of the intensified flood conditions which the records now disclose.

THE VITAL PART OF A WATERSHED.

Considering the streams which drain the mountain regions, the most vital parts of the watersheds are the highest parts. It is there that precipitation is the heaviest, slopes the steepest, and the whole sum of conditions most influential. Therefore, so far as stream flow is concerned, the mountains are the portion which should be given the most judicious care. It is on the mountains that the best condition of soil and ground cover should be maintained. As the best ground cover, as has already been explained, is the forest, it is to the benefit of the streams that the mountains should be kept densely forested, in order that the conditions for the absorption and retention of moisture may be as nearly as possible ideal. Under such conditions the course of the moisture will be one of continual interference from the time it reaches the crowns of the trees till it is in the stream.

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Every obstruction that can be placed in the way of the water aids by that much the even flow of the rivers. Under perfect forest conditions it is well-nigh impossible for any surface run-off to take place. The rain first comes into contact with the crowns of the trees, and the drops are broken more or less into spray. Some of the intercepted water runs down the trunks or drips from the branches. That which escapes interception by the trees encounters the undergrowth and brush immediately above the ground and is intercepted and retarded. As the water continues to make its way downward the ground litter offers the next obstacle. The water is caught up by the litter, and not until this has become saturated can the water pass on. If the rain continues for some time the litter becomes filled to its capacity, and then the humus begins to absorb the water which the litter can not hold. After a time it, too, becomes saturated. The water then gradually filters into and through the underlying soil. If this is deep it stores water in large quantity and then allows the surplus to pass to still greater depths, where it finally penetrates the rock strata and replenishes the great underground reservoir, from which it emerges later as springs, some of which may be far removed, even on the opposite side of the mountain, from the place where it has come in contact with the ground. If the precipitation is in the form of snow its course is substantially the same, but with a still greater delay in passing through the litter and entering the soil. The period that may elapse between the fall of rain and the appearance of water in a river varies from minutes to months or even years.

Even with the best regulated system of checking and storing the rainfall a condition may arise where, to a large extent, the effect of obstruction and storage in a forest may temporarily be lost. Severe and prolonged freezing may result in a sheet of ice in and over the upper soil, which prevents the entrance of water, and whatever falls in the form of rain must at once run off into the streams. Many rivers experience their worst floods when their drainage basins are frozen. On account of this condition is is impossible to claim that extreme floods will not come in a stream with a forested watershed. Fortunately the condition arises but seldom.

In such cases the conditions are similar to what they would be were the covering of the soil removed. The disastrous floods which come once or twice in a generation when heavy rains descend upon snow and frozen ground would probably be duplicated or surpassed yearly, or several times a year, were the soil stripped from the mountain regions. The heavy rains of summer which now fall upon a dense vegetation and hardly affect the larger rivers would then produce destructive floods.

A COMPARATIVE STUDY OF WATERSHED CONDITIONS.

The table on a preceding page gives data regarding the flow of 10 important rivers of the United States. It has not been possible to obtain for each watershed a record of the changes which are believed to be responsible for the increased flood conditions which the record shows. It has been possible to make a detailed study of parts of the watersheds of two of the streams, the Cumberland and the Red.

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A WATERSHED WHERE CONDITIONS HAVE GROWN WORSE.

The Cumberland River is a good example of how conditions have changed for the worse on some of these watersheds.

The drainage area of the Cumberland River above Burnside, Ky., comprises 3,739 square miles and lies in the heart of the Cumberland Mountains. The figures given in the table show that floods have increased in the Cumberland River at Burnside, Ky., in number from 32 in the first half to 43 in the second half, and in duration from 89 days in the first half to 102 days in the second half, while low waters have increased in times from 61 in the first half to 65 in the second half, and in days from 1,261 in the first half to 1,576 in the second half.

The removal of the forest on this watershed is progressing from three causes: (1) Clearing for agriculture; (2) lumber operations; (3) fires.

In 1890, when these measurements were begun, 21 per cent of the watershed above Burnside was cleared; in 1908 the cleared area had grown to 32 per cent. During the eight years from 1900 to 1908 clearing of forest for agricultural purposes went on on this watershed at the average rate of five-eighths of 1 per cent per year.

The total stand of timber on this part of the Cumberland watershed is 6,212,531,000 board feet. It is being cut away by lumbering alone at the rate of 4 per cent a year. These figures show that timber is disappearing on account of lumber operations eight times as fast as it is removed to clear land for farming purposes. In other words, supposing that lumbermen would cut clear as they go, 8 acres would be stripped for timber to 1 cleared for agriculture. The forest is not being cut clear. Instead, the lumberman is going over it time after time, picking out the particular kinds or classes of timber that he wants. First, he took the walnut and cherry; next, the white oak and poplar; now he is taking the chestnut and other kinds of oak. At the present time few tracts can be found from which one or more of the valuable timbers have not been culled. Other tracts have been stripped of nearly their entire growth.

At intervals of from one to five or six years fires run through the woods on the hills and mountains where the Cumberland River has its source. The fires are more frequent and destructive in districts where part of the timber has been cut and the refuse left on the ground. The dry ridges burn oftener than the coves, because the latter are sometimes too damp for burning. In times of prolonged drought, however, fires run through the ravines and coves where the densest growth is found. The fires are usually slow, and the damage to mature timber is not great, but the injury to the young growth is frequently excessive, and soil damage is serious. As a rule all seedlings and sprouts less than 4 or 5 feet high are killed, and, since fires come at intervals so frequent that the young growth can not attain a size above that, a large part of what would be the future forest, as well as the present ground cover, is destroyed. The surviving stand thus becomes thinner year by year, since it can not be replenished by young growth, and since the mature trees are steadily falling by natural decay or by the ax.

Though the fires are slow and small, they burn the leaf cover and the upper layers of humus at each visitation. This removes or injures

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the porous surface, one of whose essential functions is to arrest the storm water falling upon the slopes and afford it an opportunity to sink into the ground. With the packing of the surface, after the litter and humus have been burned away, the water flows down the slopes and quickly reaches the streams, where, if in sufficient quantity, it produces flood conditions. Low water follows, because the hard ground is able to take in but little of the storm water to be paid out slowly afterward.[a]

The behavior of the Cumberland River shows a direct and positive relation between the run-off and the changed condition of the surface. The changes due to agriculture and lumbering can be definitely stated, but the extent and effect of forest fires are not subject to exact calculation. Yet undoubtedly all of these influences are active in producing the results as shown in the flood and low water records at Burnside. It is impossible that these results should be due to rainfall, because the rainfall was approximately 10 per cent less in the second half of the period. Since no other influences could have produced the result, there is no conclusion possible other than that the progressive floods and low waters have been due to the changes accomplished on the surface of the watershed.

A WATERSHED WHERE CONDITIONS HAVE GROWN BETTER.

The fact that man by his operations may decidedly change the regimen of a river is shown not alone by those streams whose flow has been influenced by clearing away the forest. It is shown, on the other hand, by streams whose watersheds of prairie soil compacted for ages by the trampling of buffalo, and more recently by cattle of the great ranches of the West, have been to a large extent brought under cultivation.

A stream which shows this tendency in an unmistakable way is the Red River, which forms the boundary for many miles between Texas and Oklahoma. On this stream records of flow are available for sixteen years. The number of floods in the first half of this

[a] A more definite statement regarding the damage to humus by fire may be made for the upper watershed of the Potomac River. In Water-Supply Paper, No. 192, the U. S. Geological Survey shows that 838 square miles of the forest of this watershed had been so severely burned by repeated fires as to completely or almost completely destroy the humus. Other tracts aggregating twice that area had their soil severely damaged, but not to the point of complete destruction of the humus. Considered together, these burned-over lands have an area of over 2,500 square miles, or 27 per cent of the drainage basin above the point of measurement. Assuming that the humus of the uninjured forest soil of the Potomac basin would hold back for absorption 2 inches of water, and assuming that with the humus damaged as in this case the capacity of the soil for receiving water is lessened one-half, then 1 inch will be held instead of 2 inches, as formerly. In an area of 2,500 square miles, the inch of water, which formerly was absorbed but now flows away quickly, amounts to about 6,000,000,000 feet. During a heavy rain that quantity of water in excess of what would flow off quickly before would go at once to the streams.

The rating table for the Potomac at Point of Rocks, where the measurements were made, shows that when the river is at a 10-foot stage 61,000 cubic feet of water pass per second. The 6,000,000,000 cubic feet of extra flood water from the burnt forest is therefore sufficient, without a gallon from other parts of the basin, to maintain a 10-foot stage at Point of Rocks for thirty hours. The effect on succeeding low-water stages is a logical one. There is simply 6,000,000,000 cubic feet less of stored water to come gradually after the rains cease.

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period was 19; in the second half, 16. The number of days of flood in the first half was 87; in the second half, 60. Considering also the low-water periods of this river, we find that in the first half of the period there were 49 periods of low water; in the second half there were 8. In the first half the duration of low water was 826 days; in the second half, 208 days. A falling off in the rainfall occurred on this watershed, there being 1.94 inches less water per year in the second than in the first. Its drainage basin is, and has been during the time of its known history, practically without forests, only 1 acre in 10 being forested. In that respect it differs from all eastern and many western rivers whose basins are more extensively forest covered.

Why has the Red River constantly changed its flow toward steadiness and uniformity, while many other rivers have changed in exactly the opposite direction? The area of the Red River drainage basin above Arthur City, Tex., where the records were made, is 40,200 square miles, divided almost equally between Oklahoma and Texas. In this river, as in those before mentioned, the geology and topography have not changed. The precipitation has changed considerably in the direction of lessened rainfall, but not enough to account for the record. In soil conditions, and especially in the condition of the surface, however, the change has been marked. At the beginning of the period of measurement, in 1890, the country was for the most part occupied by large ranches. The native prairie sod had never been broken up.

On the part of the watershed lying in Texas there had been some settlement at an early date, but as late as 1900 no more than 12 per cent of the Texas part of the watershed had been improved. In the Oklahoma part of the basin, in the same year, the improved portion was 16 per cent. Development began most extensively about 1900. In southwestern Oklahoma, in that portion drained by the Red River, it was stimulated by the opening of Indian reservations to settlement. The Cheyenne, the Arapahoe, and the Wichita lands were opened, it is true, in 1890, but the real opening of the country to settlers came in 1901, when the Comanche, the Apache, and other Indian lands were opened, aggregating over 10,000 square miles, or more than one-fourth of the entire Red River basin above Arthur City. Another tract of over 8,000 square miles, the Choctaw and Chickasaw lands, began its development about the same time. A summary of these figures shows that in 1908 the Red River basin in Oklahoma had 10,200 square miles of improved land, instead of 3,284 square miles in 1900. Statistics are not complete for the Texas portion of this basin, but the Texas portion has developed at about the same rate as the Oklahoma part. It is probable that the whole Red River basin above Arthur City, in Texas and Oklahoma, had 40 per cent of its land under improvement in 1908, instead of 14 per cent eight years earlier.

The results which have appeared in the form of change of the flow in the Red River are precisely what ought to be expected from the changes in surface conditions. Theoretically, such results should appear, and as a matter of fact, they have appeared. The hardened prairie soil has been broken up and changed into cultivated fields over 40 per cent of the area, and thereby the absorptive capacity of the soil has been much increased. Over the remainder prairie fires have been kept out and better growth of grass secured. The extensions of cultivation and the improvement of the grass land has

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tended to equalize the flow of this river. The river's behavior has become better as the area of wild land has decreased. In other words, wild, barren land, being the worst condition for the protection of a watershed, and cultivated farm lands being next to forests the best condition, the change of a large part of the watershed from the worst condition to the next to the best condition has brought about this result.

The same law is thus seen to work on both the Cumberland and the Red River watersheds, but in different directions. On the Cumberland, as the watershed changes from the forest (the best condition for stream protection) to farm land, to pasture land, and even to barren condition (the very worst condition for absorption), the flow of the river is made more extreme, both as to floods and low waters. On the Red watershed, beginning with a wild, almost barren, compacted surface, cultivation has changed the condition to that of permeable farm lands, which, next to forests, offer the best conditions. These two extremes exemplify, therefore, in different directions, the working of the same law—that there is a vital relation between the condition of the surface of the watershed and the manner of flow of the stream which drains it.

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DENUDATION.

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INTRODUCTION.

The accompanying tables present estimates of the rate of denudation in the United States. The figures show the rate at which the earth's crust is being moved as solid particles carried in suspension by streams and as matter carried in aqueous solution. The first table is a summary of the estimated denudation for the whole United States and for the primary drainage basins; the other tables contain detailed estimates for smaller areas. The map indicates graphically the rates of denudation in different parts of the country.

SOURCES OF DATA.

The computations of denudation factors are based on figures representing the amount of mineral matter carried by streams, the size of the areas tributary to the streams, and the quantity of water discharged by the streams. The run-off data are derived principally from measurements made by the water-resources branch of the United States Geological Survey; some of the measurements, especially in lower Mississippi Valley and on the Great Lakes, were made by the Engineer Corps, U. S. Army; the Weather Bureau, Department of Agriculture, has contributed series of gage heights in several streams; and estimates of run-off based on the best available information have been made for areas regarding which no measurements are at hand. The estimates of the size of the drainage basins are either copied from printed reports or measured from the best available maps. The greater part of the chemical data are derived from complete mineral analyses of river waters, about 5,000 in all, performed for the water-resources branch under the direction of R. B. Dole by W. M. Barr, F. W. Bushong, C. K. Calvert, W. D. Collins, F. M. Eaton, J. R. Evans, P. L. McCreary, Chase Palmer, J. L. Porter, M. G. Roberts, F. C. Robinson, Walton Van Winkle, and A. J. Weith. Daily samples of water were collected for one year from about 150 rivers and lakes in California and in the States east of the one hundredth meridian. Ten consecutive samples were then united and the composites thus obtained were subjected to complete mineral analysis. The information regarding dissolved and suspended matter in the streams of the arid States, except California, has been furnished by the United States Reclamation Service from work

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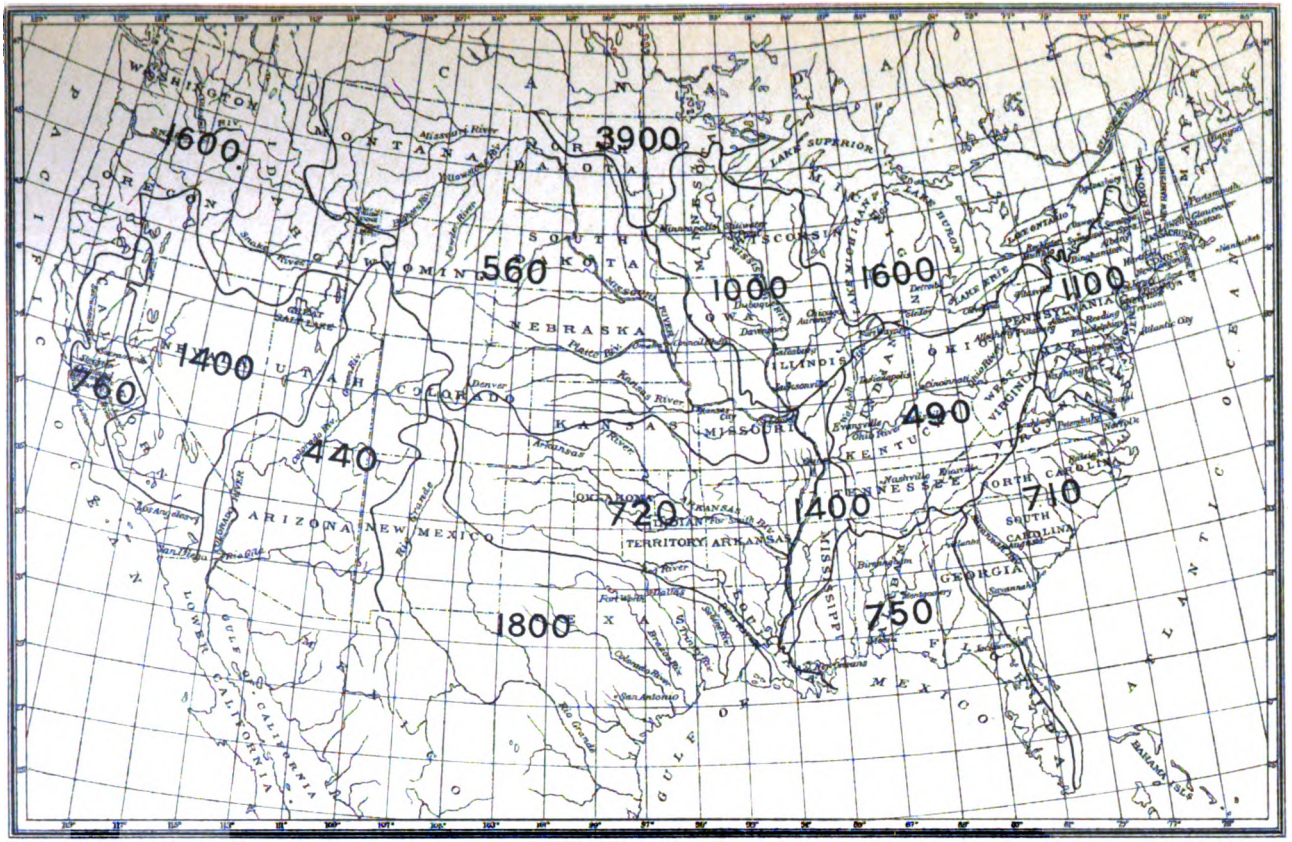

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RATES OF DENUDATION IN THE UNITED STATES

The figures are the number of years required for one inch of denudation.

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done under the direction of W. H. Heileman, but unfortunately the detailed analyses could not be procured and therefore the comparative accuracy of the estimates is unknown. In the California and the Reclamation Service work 50 cubic centimeters of filtered and 50 cubic centimeters of unfiltered sample were evaporated, dried at 110° C., and weighed to determine suspended and dissolved solids. In the other analyses the suspended matter in 500 cubic centimeters of the sample was removed by filtration through a Gooch crucible, dried at 180° C., and weighed for suspended solids; the filtrate was then evaporated, dried at 180° C., and weighed for dissolved solids. Some error is introduced by comparing solids determined at 180° with solids determined at 110°. The size of the error varies with the amount of organic matter and water of crystallization present and with the character of the solids themselves, and is probably variable for different rivers and for the same river from time to time; consequently no correction for it has been made. In most cases, however, this circumstance introduces less than 10 per cent error.

The figures for Kennebec River are computed from analyses by G. C. Whipple and E. C. Levy. The dissolved solids for Connecticut River and for Housatonic River are from reports of the Connecticut state board of health; for Merrimac River, from reports of the Massachusetts state board of health; for Blackstone River, from reports of the Rhode Island state board of health. The data for Hudson River at Albany, N. Y.; Potomac River at Great Falls, Md.; and Allegheny River at Pittsburg, Pa., are from reports of water-supply investigations at those places. The figures for Colorado River at Yuma, Ariz., are computed from analyses by R. H. Forbes and from others made in continuation of his work by the Reclamation Service. The data for Ohio River at Louisville, Ky., and at Cincinnati, Ohio, are quoted from reports by G. W. Fuller. The data at West Alton and at Jefferson Barracks, Mo., are quoted from analyses by A. W. Palmer in connection with the case of the State of Missouri against the State of Illinois and the sanitary district of Chicago. The estimates of suspended and dissolved solids at New Orleans, La., are computed from fifteen years' sediment determinations by the Engineer Corps, U. S. Army, and from five years' determinations by the New Orleans water and sewerage board. In all the quoted analyses the estimates are given by weight and not by volume, and in nearly all cases they show the average condition of the water for one or more years.

METHODS OF COMPUTATION.

The estimates of denudation, computed from the above-mentioned data by H. Stabler, indicate the removal in solution and suspension of solids from the primary and secondary drainage basins of the United States as classified by the Geological Survey. The determinations on which the computations are based are given in detail. The eleven primary basins are designated by Roman numerals. Under the secondary basins, which are designated by Arabic figures, important tributaries and the sampling stations are indicated.

The second, third, fourth, and fifth columns of the tables give, respectively, the areas of the basins, the dissolved solids, the sus-

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pended solids, and the annual run-off per square mile. In columns 6 and 7 the annual denudation in tons per square mile for the areas above the points at which samples were collected is computed by multiplying together solids in parts per 1,000,000, run-off in second-feet per square mile, and 0.985; in all other regions the denudation is estimated from the data for known areas. Columns 8 and 9 show the total denudation in thousands of tons per year, computed for the secondary areas by multiplying denudation in tons per square mile per year by the drainage area in thousands of square miles.

The depth in millionths of an inch per year covered by the material removed is found by dividing the tons per square mile per year by 0.1917 and the last three columns bear reciprocal relations to columns 10, 11, and their sum. Any attempt to estimate erosion in volumetric terms from determinations of dry suspended matter and dissolved solids involves the use of factors which are by no means absolute. The actual specific gravity of the mineral substance carried in streams in the United States is not greatly different from 2.6. This figure is practically identical with that commonly assumed for the specific gravity of the earth's crust and corresponds to a weight of 165 pounds per cubic foot. Each 165 pounds of substance found in water, therefore, represents the erosion of approximately 1 cubic foot of the crust of the earth, and estimates of ultimate rock losses based upon these figures are probably not in error more than 8 or 10 per cent. Common earth or loam, however, contains a large amount of air space, or voids, and dry earth is estimated as weighing 80 to 110 pounds per cubic foot. If an estimate of erosion be made upon this basis the error for a large area will probably not be great, but may amount to 20 per cent or more when calculations are made for small areas. Finally a third factor for calculation is based upon an attempt to determine the volume of river sediment or mud banks that a given weight of suspended matter may form. Investigators working upon different streams in the United States have obtained results indicating that a cubic foot of sediment may be produced by 50 to 125 pounds of dry material. The compactness of the mud is so variable that an estimate of this nature based upon an average of 90 pounds per cubic foot is likely to be in error by about 45 per cent. In view of the widely divergent values given for river sediment and for surface loam, the estimates for denudation expressed in millionths of an inch in depth from the entire drainage area and in years required for the erosion of 1 inch from the drainage area are based upon the assumption that 165 pounds of suspended or dissolved solids represent the removal of 1 cubic foot of the earth's crust. The factor 0.1917 has been computed on that basis. For the convenience of those who prefer a different basis of calculation, the following table of ratios is presented. The figures given in this report for denudation in inches can be recomputed by dividing them by the ratio corresponding to the weight given in column 1.

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Ratios for recomputing denudation in inches.

Weight of material per cubic foot.	Corresponding specific gravity.	Ratio.
Pounds.		
165	2.64	1.00
150	2.40	.91
140	2.24	.85
130	2.08	.79
120	1.92	.73
110	1.76	.67
100	1.60	.61
90	1.44	.55
80	1.28	.49
70	1.12	.42
60	.96	.36
50	.80	.30

The estimates for the primary basins and for the whole United States are based upon the estimates for the secondary areas.

PROBABLE ACCURACY.

The majority of the figures for run-off per square mile per year are based upon discharge measurements extending over periods of seven years or more and are, with a few exceptions, within 10 per cent of the true average values. The drainage areas in square miles are so nearly correct that their errors are negligible in these calculations. The estimates of dissolved solids represent the average condition of the water for a period of one year or more. By comparison of annual averages for several streams in different years it has been estimated that the average for one year is generally not over 10 per cent from the correct average value, and it is undoubtedly true that the average total solids does not vary from year to year nearly so much as the average run-off. On the other hand, suspended solids are subject to greater variation than run-off. Floods are always attended by extreme rises in suspended solids, and the amount of suspended matter is subject to enormous variation from place to place on account of changes in stream velocity, the character of the river bed, and other features. In consequence of these facts, it is possible that denudation estimates, based on average suspended matter for one year, may be in error as much as 50 per cent. When all these facts are considered in conjunction with the distance of the sampling stations from the mouths of the rivers, it may be estimated that the calculated figures for denudation are generally within 20 per cent of the true values. Only two significant figures, therefore, have been retained in the last five columns. In many streams of the arid and semiarid regions the yearly fluctuations in run-off are very great and the mineralization of the waters is very high, so that estimates of denudation in that part of the country are not so reliable as similar estimates for eastern rivers. As the analytical data for the northern Pacific, Hudson Bay, and western Gulf of Mexico basins are extremely meager, the estimated denudations for those areas may be more than 20 per cent in error, and further investigations in those regions must be made before reliable values can be calculated.

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DISCUSSION OF SUMMARY.

The summary presents in tabular form denudation estimates for the primary drainage basins and for the whole United States. The figures for dissolved solids practically represent material carried into the ocean; the figures for suspended solids, on the other hand, represent more properly material carried to tide water, because the decrease in stream velocity at that point occasions a gradual deposition of the matter transported in solid form. The tons per square mile per year removed from different basins show interesting comparisons. In respect to dissolved matter, the southern Pacific basin heads the list with 177 tons, the northern Atlantic basin being next with 130 tons. The rate for Hudson Bay basin, 28 tons, is lowest; that for the Colorado and western Gulf of Mexico basins is somewhat higher. The denudation estimates for the southern Atlantic basin correspond very closely to those for the entire United States. The amounts are generally lowest for streams in the arid and semiarid regions, because large areas there contribute little or nothing to the run-off. The southern Pacific basin is an important exception to this general rule, presumably because of the extensive practice of irrigation in that area. The amounts are highest in regions of high rainfall, though usually the waters in those sections are not so highly mineralized as the waters of streams in arid regions.

Colorado River brings down the most suspended matter, delivering 387 tons per year for each square mile of its drainage basin. Though many small streams bring silt into the Great Lakes, sedimentation clears the water, and practically no suspended matter is transported by St. Lawrence River. In general much less suspended matter is carried by northern than by southern rivers, a phenomenon influenced probably more by the texture of the soil and the subsoil and the geologic character of the rocks than by stream velocity.

The detailed estimates throw considerable light upon the progress of erosion in different sections of the river valleys. The Mississippi, for instance, apparently discharges more material than is brought in by its tributaries, thus indicating that its lower valley is still being eroded. The lower Colorado, however, appears to be receiving deposits from both dissolved and suspended matter taken from its upland drainage area. The Rio Grande is similar to the Colorado in this respect.

The estimates reveal that the surface of the United States is being removed at the rate of thirteen ten-thousandths of an inch per year, or 1 inch in 760 years. Though this amount seems trivial when spread over the surface of the country, it becomes stupendous when considered as a total, for over 270,000,000 tons of dissolved matter and 513,000,000 tons of suspended matter are transported to tide water every year by the streams of the United States. This total of 783,000,000 tons represents more than 350,000,000 cubic yards of rock substance, or 610,000,000 cubic yards of surface soil. If this erosive action had been concentrated upon the Isthmus of Panama at the time of American occupation, it would have excavated the prism for an 85-foot level canal in about seventy-three days.

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Summary.

Drainage basin.	Physical and chemical data.				Estimated denudation.								
	Area (square miles).	Solids (parts per million).		Run-off (second-feet per square mile).	Tons of solids per square mile per year.		Thousand tons of solids per year.		Millionths of an inch per year.		Years required for 1 inch.		
		Dissolved.	Suspended.		Dissolved.	Suspended.	Dissolved.	Suspended.	Dissolved.	Suspended.	Dissolved.	Suspended.	Total.
I. Northern Atlantic	159,400				130	39	20,800	6,100	680	200	1,500	5,000	1,100
II. Southern Atlantic	123,900				94	176	11,700	21,800	490	920	2,000	1,100	710
III. Eastern Gulf of Mexico	142,100				117	144	16,600	20,400	580	750	1,700	1,300	750
IV. Western Gulf of Mexico	315,700				36	72	11,400	22,700	190	380	5,300	2,700	1,800
V. Mississippi River	1,265,000				108	269	136,400	340,500	560	1,400	1,800	710	500
VI. Laurentian Basin	175,000				116	1	20,400	180	600	5	1,700	200,000	1,610
VII. Colorado River	230,000				51	387	11,700	89,000	270	2,000	3,800	500	440
VIII. Southern Pacific	72,700				177	75	12,800	5,500	920	390	1,100	2,600	760
IX. Northern Pacific	270,000				100	20	27,000	5,400	520	100	1,900	9,600	1,600
X. Great Basin	223,000				90	50	20,100	11,200	470	260	2,100	3,800	1,400
XI. Hudson Bay	62,000				28	21	1,700	1,300	150	110	6,800	9,100	3,900
Total	3,048,800						290,600	524,080					
The United States	3,088,500				94	170	290,600	524,080	490	890	2,040	1,130	730
The United States (Great Basin denudation being taken as zero)	3,088,500				87	166	270,500	512,880	460	870	2,190	1,150	760

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Detailed estimates.

Drainage basin.	Physical and chemical data.				Estimated denudation.								
	Area (square miles).	Solids (parts per million).		Run-off (second-feet per square mile).	Tons of solids per square mile per year.		Thousand tons of solids per year.		Millionths of an inch per year.		Years required for 1 inch.		
		Dissolved.	Suspended.		Dissolved.	Suspended.	Dissolved.	Suspended.	Dissolved.	Suspended.	Dissolved.	Suspended.	Total.
I. Northern Atlantic	159,400				130	39	20,795	6,147	680	200	1,500	5,000	1,100
1. St. Johns (in United States)	7,500			1.76	85	7	638	53	440	37	2,300	27,000	2,100
2. St. Croix (in United States)	1,100			2.61	100	8	110	9	520	42	1,900	24,000	1,800
3. Penobscot	8,500			1.96	90	8	765	68	470	42	2,100	24,000	2,000
4. Kennebec	5,970			1.84	85	7	508	42	440	37	2,300	27,000	2,100
Waterville, Me.	4,270	48	4.0	1.76	83	7.3							
5. Androscoggin	3,500			2.14	100	8	350	28	520	42	1,900	24,000	1,800
Brunswick, Me.	3,500	48		2.14	101								
6. Presumpscot	600			1.68	85	7	51	4	440	37	2,300	27,000	2,100
7. Saco	1,720			2.36	100	8	172	14	520	42	1,900	24,000	2,100
8. Merrimac	5,020			1.62	65	7	326	35	340	37	3,000	27,000	2,700
Lawrence, Mass.	4,550	41		1.58	64								
9. Connecticut	11,100			1.99	90	8	999	89	470	42	2,100	24,000	2,000
Goodspeeds, Conn.	10,900	45		1.99	88								
10. Blackstone	460				125	7	58	3	650	37	1,500	27,000	1,500
Valley Falls, R. I.	440	74		1.71	125								
11. Thames	1,450				125	7	181	10	650	37	1,500	27,000	1,500
12. Housatonic	1,980			2.17	195	8	386	16	1,000	42	980	24,000	940
Gaylordsville, Conn.	1,020		4.0	2.15		8.5							
Derby, Conn.	1,920	92		2.15	195								
13. Hudson	13,400			1.90	190	30	2,544	402	990	160	1,000	6,400	870
Albany, N. Y.	8,800	107	17.0	1.80	189	30							
Hudson, N. Y.	9,530	108	16.0	1.82	193	29							
Mechanicsville, N. Y.	4,500			1.81									
Dunsback Ferry (Mohawk River)	3,440			1.73									
14. Passaic	950			2.17	180	75	171	71	940	390	1,100	2,600	750
15. Raritan	1,110			2.15	180	75	200	83	940	390	1,100	2,600	750
Bound Brook, N. J.	800	85	36.0	2.14	179	76							
16. Delaware	13,100			1.97	150	55	1,964	721	780	290	1,300	3,500	940
Lambertville, N. J.	6,860	70	26.0	2.19	151	56							
17. Susquehanna	27,400			1.56	165	35	4,520	960	860	180	1,200	5,500	960
Danville, Pa.	11,070	112	21.0	1.71	188	35							
Williamsport, Pa.	5,640	74	18.0	1.68	123	30							
18. Potomac	14,300			1.21	125	95	1,787	1,358	650	500	1,500	2,000	870
Piedmont, W. Va.	410			1.70									

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Cumberland, Md.	620	130	29.0	1.70	217	49							
Millville, W. Va. (Shenandoah River)	3,000	140	39.0	1.07	147	41							
Point of Rocks, Md.	9,650			1.07									
Great Falls, Md.	11,400	115	85.0	1.12	127	94							
19. James	10,400			1.35	115	95	1,195	988	600	500	1,700	2,000	900
Cartersville, Va.	6,230			1.33									
Richmond, Va.	6,820	89	71.0	1.33	117	93							
20. Minor Chesapeake Bay	12,800			1.59	} 130	40	3,870	1,193	680	210	1,500	4,800	1,100
21. Minor North Atlantic	17,000			2.18									
II. Southern Atlantic	123,900				94	176	11,688	21,775	490	920	2,000	1,100	710
1. Chowan	5,000			1.40	85	80	425	400	440	420	2,300	2,400	1,200
2. Roanoke	9,750			1.25	101	256	984	2,490	530	1,300	1,900	750	540
South Boston, Va. (Dan River)	2,750	71	264.0	1.34	94	348							
Randolph, Va.	3,080	79	127.0	1.39	108	174							
3. Tar	4,360			1.26	85	80	371	349	440	420	2,300	2,400	1,200
4. Neuse	5,550			1.32	86	80	477	444	450	420	2,200	2,400	1,200
Raleigh, N. C.	1,000	73	68.0	1.19	86	80							
Selma, N. C.	1,170			1.19									
5. Cape Fear	9,030			1.23	69	25	623	226	360	130	2,800	7,700	2,000
Wilmington, N. C.	9,030	57	21.0	1.23	69	25							
6. Pedee (Yadkin)	10,600			1.60	113	154	1,198	1,630	590	800	1,700	1,200	720
Sallsbury, N. C.	3,400			1.69									
Pee Dee, N. C.	6,100	69	94.0	1.66	113	154							
7. Santee	14,800			1.66	107	233	1,583	3,445	560	1,200	1,800	820	560
Camden, S. C. (Wateree River)	4,500	73	214.0	1.44	104	303							
Waterloo, S. C. (Saluda River)	1,060			1.85									
Columbia, S. C. (Saluda River)	2,350	62	54.0	1.85	113	98							
8. Savannah	11,100			1.58	98	232	1,088	2,575	510	1,200	2,000	830	580
Augusta, Ga.	7,300	60	142.0	1.66	98	232							
9. Ogeechee	5,140			1.27	90	225	463	1,156	470	1,200	2,100	850	610
10. Altamaha	14,100			1.26	85	215	1,198	3,030	440	1,100	2,300	890	640
Macon, Ga. (Ocmulgee River)	2,420	69	174.0	1.31	86	224							
Dublin, Ga. (Oconee River)	4,180	68	171.0	1.24	83	209							
11. Minor South Atlantic	34,500				95	175	3,278	6,030	500	910	2,000	1,100	710
III. Eastern Gulf of Mexico	142,100				117	144	16,610	20,430	580	750	1,700	1,300	750
1. Suwanee	9,970			1.50	100	150	997	1,500	520	780	1,900	1,300	770
2. Apalachicola	18,800			1.61	103	159	1,936	2,988	540	830	1,900	1,200	730
Albany, Ga. (Flint River)	5,000	67	58.0	1.56	103	89							
West Point, Ga. (Chattahoochee River)	3,300	52	136.0	1.98	102	265							
3. Mobile	42,100			1.57	129	151	5,190	6,350	670	790	1,500	1,300	680
Selma, Ala. (Alabama River)	15,400	82	100.0	1.81	146	178							
Epes, Ala. (Tombigbee River)	8,830	94	100.0	1.06	98	104							

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Detailed estimates—Continued.

Drainage basin.	Physical and chemical data.				Estimated denudation.								
	Area (square miles).	Solids (parts per million).		Run-off (second-feet per square mile).	Tons of solids per square mile per year.		Thousand tons of solids per year.		Millionths of an inch per year.		Years required for 1 inch.		
		Dissolved.	Suspended.		Dissolved.	Suspended.	Dissolved.	Suspended.	Dissolved.	Suspended.	Dissolved.	Suspended.	Total.
III. Eastern Gulf of Mexico—Continued.													
4. Pearl	8,650			1.42	75	58	649	502	390	300	2,600	3,300	1,400
Jackson, Miss.	3,120	59	46.0	1.29	75	58							
5. Minor Eastern Gulf	62,700			1.50	125	145	7,838	9,090	650	760	1,500	1,300	710
IV. Western Gulf of Mexico	315,700				36	72	11,370	22,740	190	380	5,300	2,700	1,800
1. Brazos	48,800			.200									
Waco, Tex.	32,300	1,136	1,188.0	.082	92	96	2,970	3,100					
2. Colorado (of Texas)	39,000			.097	24	26							
Austin, Tex.	35,000	321	351.0	.075	24	26	878	952					
3. Rio Grande	248,000			.032									
United States area	130,000				25	78	3,250	10,140					
El Paso, Tex.	38,600	700	14,140.0	.030	21	418							
Laredo, Tex. (United States area)	123,000	791	2,475.0	.032	25	78							
Pecos River	56,000				90	60							
Dayton, N. Mex.	16,300	2,988	2,150.0	.032	94	68							
Carlsbad, N. Mex.	19,800	2,690	331.0	.035	92	11							
V. Mississippi River:													
1. Main stream—													
Minneapolis, Minn.	19,600	200	7.9	.810	159	6.3	3,120	124	830	33	1,200	30,000	1,200
Quincy, Ill.	135,500	203	119.0	.538	108	63							
Jefferson Barracks, Mo.	700,700	206	964.0	.263	53	250							
Menard, Ill.	711,900	269	634.0	.263	70	164							
Memphis, Tenn.	941,000	202	519.0	.546	109	279							
New Orleans, La.	1,261,000	190	600.0										
At mouth	1,265,000			.560	105	331							
2. Minor lower eastern—													
Tributaries	29,000				80	60	2,320	1,740	420	310	2,400	3,200	1,400
3. Ohio River	214,000				190	200	40,600	42,750	990	1,000	1,000	960	490
Tennessee River	39,000				159	200							
Chattanooga, Tenn.	21,400			1.71									
Gilbertsville, Ky.	38,400	101	127.0	1.60	159	200							
Cumberland River	18,600				171	227							
Kuttawa, Ky.	18,200	124	165.0	1.40	171	227							

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Green River	8,580				165	225							
Kentucky River	7,870				164	220							
Frankfort, Ky	5,140	104	142.0	1.60	164	223							
Licking River	3,300				160	220							
Big Sandy River	4,000				160	200							
Kanawha River	11,000				160	180							
Monongahela River	7,620				217	203							
Elizabeth, Pa	5,590	81	84.0	1.80	143	149							
McKeesport, Pa. (Youghlogheny River)	1,770	197	163.0	2.30	446	369							
Allegheny River	11,100				160	60							
Kittanning, Pa	8,690	87	30.0	1.62	139	48							
Brilliant, Pa	11,000	116	48.0		185	77							
Beaver River	3,100				180	65							
Muskingum River	7,740				232	67							
Zanesville, Ohio	5,830	244	70.0	.966	232	67							
Scioto River	6,400				220	68							
Great Miami River	5,400				210	68							
Dayton, Ohio	2,450	289	94.0	.737	210	68							
Wabash River	33,000				249	86							
Terre Haute, Ind	12,200			.737									
Vincennes, Ind	12,720	336	193.0		244	140							
White River	10,800				290	38							
Indianapolis, Ind. (West Fork)	1,520	450	38.0	.792	351	30							
Azalia, Ind. (East Fork)	2,100	279	48.0	.900	247	43							
Shoals, Ind. (East Fork)	4,900			.924									
Embarass River	2,450				212	49							
Lawrenceville, Ill	2,390	283	66.0	.76	212	49							
Little Wabash River	2,600				133	52							
Carmi, Ill	2,500	176	68.0	.77	133	52							
Minor tributaries	56,800												
Main stream:													
Wheeling, W. Va	23,800			1.72									
Cincinnati, Ohio	72,400	120	230.0	1.60	189	363							
Louisville Ky	85,000	150	350.0	1.50	221	517							
4. Big Muddy River	2,370				170	98	400	230	890	510	1,100	2,000	720
Murphysboro, Ill	2,250	225	129.0	.77	170	98							
5. Kaskaskia River	5,880				180	92	1,060	540	940	480	1,100	2,100	700
Carlyle, Ill	2,720	248	126.0	.74	180	92							
6. Illinois River	27,900				218	118	6,080	3,290	1,100	620	880	1,600	570
Kampsville, Ill	26,730	267	145.0	.83	218	118							
7. Rock River	10,970				200	180	2,190	1,970	1,000	940	960	1,100	500
Rockton, Ill	6,150			.773									
Rock Falls, Ill	8,640	267	236.0		203	179							
8. Wisconsin River	12,280				140	7	1,720	86	730	37	1,400	27,000	1,300
Necedah, Wis	5,800			1.45									
Portage, Wis	8,600	98	4.6		140	6.6							
9. Chippewa River	9,570				116	5	1,110	48	600	26	1,700	38,000	1,600
Eau Claire, Wis	6,740	90	3.7	1.31	116	4.7							
10. St. Croix River	7,660				120	5	920	38	630	26	1,600	38,000	1,500

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Detailed estimates—Continued.

Drainage basin.	Physical and chemical data.				Estimated denudation.								
	Area (square miles).	Solids (parts per million).		Run-off (second-feet per square mile).	Tons of solids per square mile per year.		Thousand tons of solids per year.		Millionths of an inch per year.		Years required for 1 inch.		
		Dissolved.	Suspended.		Dissolved.	Suspended.	Dissolved.	Suspended.	Dissolved.	Suspended.	Dissolved.	Suspended.	Total.
V. Mississippi River—Continued.													
11. Minor upper:													
Eastern tributaries	10,000				180	90	1,800	900	940	470	1,100	2,100	710
12. Minnesota River	16,100				89	26	1,420	418	460	140	2,200	7,400	1,700
Mankato, Minn	13,400			0.186									
Shakopee, Minn	15,100	480	142.0		88	26							
13. Wapsipinicon River	2,570				145	50	370	128	760	260	1,300	3,800	980
14. Iowa River	12,400				145	50	1,800	620	760	260	1,300	3,800	980
Iowa City, Iowa	3,320	247	120.0	.573	139	68							
Cedar Rapids, Iowa (Cedar River)	6,320	228	61.0	.656	147	39							
15. Des Moines River	14,700				169	349	2,480	5,130	880	1,800	1,100	550	370
Keosauqua, Iowa	14,300	312	642.0	.551	169	349							
16. Missouri River	528,000				50	290	26,400	153,100	260	1,500	3,800	660	560
Florence, Nebr	323,000	454	2,059.0	.154	69	312							
Omaha, Nebr	323,000			.154									
Kansas City, Mo	430,000	426	2,032.0	.143	60	286							
Ruegg, Mo	528,000	346	1,890.0	.157	53	292							
West Alton, Mo	528,000	294	1,138.0	.157	45	176							
Milk River	26,700												
Havre, Mont	7,300	712	1,331.0	.035	25	46							
Yellowstone River	69,700												
Glendive, Mont	66,090	375	853.0	.188	70	158							
Platte River	83,800												
Fremont, Nebr	71,400	302	392.0		39	51							
Columbus, Nebr	70,400			.132									
Kansas River	61,400												
Lecompton, Kans	58,600			.191									
Holliday, Kans	61,100	383	612.0		72	115							
17. Arkansas River	189,000				120	140	22,700	26,450	630	730	1,600	1,400	740
Arkansas City, Kans	44,500	1,284	1,736.0	.045	57	77							
Little Rock, Ark	158,000	630	748.0	.197	122	145							
18. Red River	90,000				160	240	14,400	21,600	840	1,300	1,200	800	480
Shreveport, La	56,900	561	870.0	.285	157	244							
19. Minor western tributaries	63,000				145	50	9,140	3,150	760	260	1,300	3,800	980

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Cumulative summary:													
1. Above Quincy, Ill.:													
Mississippi at Minneapolis, Minn	19,600				159	6.3	3,120	124	830	33	1,200	30,000	1,200
Minnesota River	16,100				88	26	1,420	418	460	140	2,200	7,400	1,700
Wapsipinicon River	2,570				145	50	370	128	760	260	1,300	3,800	980
Iowa River	12,400				145	50	1,800	620	760	260	1,300	3,800	980
Des Moines River	14,700				169	349	2,480	5,130	880	1,800	1,100	550	370
St. Croix River	7,660				120	5	920	38	630	26	1,600	38,000	1,500
Chippewa River	9,570				116	5	1,110	48	600	26	1,700	38,000	1,600
Wisconsin River	12,280				140	7	1,720	86	730	37	1,400	27,000	1,300
Rock River	10,970				200	180	2,190	1,970	1,000	940	960	1,100	500
Minor streams	29,650				157	63	4,660	1,880	820	330	1,200	3,000	870
Mississippi at Quincy, Ill	135,500												
Estimated from tributaries					146	77	19,790	10,442	760	400	1,300	2,500	860
Actually determined					108	63	14,640	8,540	560	330	1,800	3,000	1,100
Average					127	65	12,215	9,491	660	340	1,500	3,000	1,000
2. Above Menard, Ill.:													
Mississippi at Quincy, Ill	135,500				146	77	19,790	10,442	760	400	1,300	2,500	860
Illinois River	27,900				218	118	6,080	3,290	1,100	620	880	1,600	570
Missouri River	528,000				50	290	26,400	153,100	260	1,500	3,800	660	560
Kaskaskia River	5,880				180	92	1,060	540	940	480	1,100	2,100	700
Minor streams	14,620				145	50	2,120	731	760	260	1,300	3,800	980
Mississippi at Menard, Ill	711,900												
Estimated from tributaries					78	236	55,450	168,103	410	1,200	2,500	810	610
Actually determined					70	164	49,850	116,700	360	860	2,700	1,200	820
Average					74	200	52,650	142,402	390	1,000	2,600	960	700
3. Above Memphis, Tenn.:													
Mississippi at Menard, Ill	711,900				78	236	55,450	168,103	410	1,200	2,500	810	610
Big Muddy River	2,370				170	98	400	230	890	510	1,100	2,000	720
Ohio River	214,000				190	200	40,600	42,750	990	1,000	1,000	960	490
Minor streams	12,730				145	50	1,840	636	760	260	1,300	3,800	980
Mississippi at Memphis, Tenn	941,000												
Estimated from tributaries					104	225	98,290	211,719	540	1,200	1,800	850	580
Actually determined					109	279	102,500	262,400	570	1,500	1,800	690	490
Average					106	252	100,395	237,060	550	1,300	1,800	760	540

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Detailed estimates—Continued.

Drainage basin.	Physical and chemical data.				Estimated denudation.								
	Area (square miles).	Solids (parts per million).		Run-off (second-feet per square mile).	Tons of solids per square mile per year.		Thousand tons of solids per year.		Millionths of an inch per year.		Years required for 1 inch.		
		Dissolved.	Suspended.		Dissolved.	Suspended.	Dissolved.	Suspended.	Dissolved.	Suspended.	Dissolved.	Suspended.	Total.
V. Mississippi River—Continued. Cumulative summary—Continued.													
4. Mouth of river:													
Mississippi at Memphis, Tenn.	941,000				104	225	98,290	211,719	540	1,200	1,800	850	580
Arkansas River	189,000				120	140	22,700	26,450	630	730	1,600	1,400	740
Red River	90,000				160	240	14,400	21,600	840	1,300	1,200	800	480
Minor streams	45,000				103	56	4,640	2,540	540	290	1,900	3,400	1,200
At mouth	1,265,000												
Estimated from tributaries					111	208	140,030	262,309	580	1,100	1,700	920	600
Determined from analyses at New Orleans					105	331	132,820	418,720	550	1,700	1,800	580	440
Average					108	269	136,425	340,514	560	1,400	1,800	710	510
VI. Laurentian Basin: [a]													
United States area	175,000				116	1	20,360	181	600	5	1,700	200,000	1,600
1. Lake Superior	76,100			1.02	60	1							
United States area	48,600				60	1	2,920	49	310	5	3,200	200,000	3,100
Saulte Ste. Marie, Mich.	76,100	60	Trace.										
2. Lakes Michigan-Huron	137,800			.874									
United States area	71,300				126	.8	8,950	59	660	4	1,500	250,000	1,500
3. Lakes Superior-Michigan-Huron	213,900			.924	99	.9							
United States area	119,900				99	.9	11,870	108	520	5	1,900	200,000	1,900
Chicago, Ill. (drainage canal)	213,900	130	Trace.	.022	3	.0							
Port Huron, Mich. (St. Clair River)	213,900	108	Trace.	.902	96	.9							
4. Lake Erie	40,800			.539									
United States area	23,400				184	.5	4,310	11	960	3	1,000	330,000	1,000
5. Lakes Superior-Michigan-Huron-Erie	254,700			.863	113	.8							
United States area	143,300				113	.8	16,180	119	590	4	1,700	250,000	1,700
Chicago, Ill. (drainage canal)	254,700	130	Trace.	.018	2.3	.0							

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Buffalo, N. Y. (Niagara River and New York canals)	254,700	133	Trace.	.845	111	.8							
6. Lake Ontario	33,000			1.04									
United States area	18,000				144	1	2,600	18	750	5	1,300	200,000	1,300
7. Lakes Superior-Michigan-Huron-Erie-Ontario	287,700			.884	116	.9							
United States area	161,300				116	.9	18,780	137	600	5	1,700	200,000	1,600
Chicago, Ill. (drainage canal)	287,700	130	Trace.	.016	2.1	.0							
Buffalo, N. Y. (New York canals)	287,700	133	Trace.	.008	1.1	.0							
Ogdensburg, N. Y. (St. Lawrence River)	287,700	134	Trace.	.859	113	.9							
8. St. Lawrence River (below Ogdensburg, N. Y.)—													
United States area	13,660				116	3.2	1,580	44	600	17	1,700	59,000	1,600
Oswegatchie River—													
Ogdensburg, N. Y.	1,580	77	10.0	1.72	130	17							
Lake Champlain	7,900	66	Trace.		113	1.7							
Rouses Point, N. Y.	7,750			1.74									
VII. Colorado River:													
United States area	230,000				51	387	11,730	89,010	270	2,000	3,800	500	440
Yuma, Ariz	225,000	710	5,354.0	.0733	51	387							
1. Gila	71,100				80	[b] 225	5,690	16,000	420	1,200	2,400	860	630
Salt River	13,000				150	235							
Roosevelt, Ariz	5,760	646	1,300.0	.238	151	304							
McDowell, Ariz. (Verde River)	6,000	363	1,137.0	.141	50	158							
Mesa, Ariz	12,260	1,090	1,274.0	.189	203	237							
Gila River					13	210							
San Carlos, Ariz	13,500	811	4,682.0	.015	12	69							
Florence, Ariz	17,850	944	14,130.0	.015	14	209							
2. Little Colorado	31,000				11	134	340	4,150	57	700	18,000	1,400	1,300
Woodruff, Ariz	6,000	602	7,149.0	.019	11	134							
3. Grand	26,200				198	470	5,190	12,310	1,000	2,400	970	410	[b] 290
Palisades, Colo	8,550	[c] 429	[c] 1,358.0	.546	230	730							
Whitewater, Colo. (Gunnison River)	7,870	484	553.0	.350	167	190							
4. Green	41,000				90	165	3,690	6,760	470	860	2,100	1,200	750
Jensen, Utah	26,600	369	679.0	.247	90	165							
VIII. Southern Pacific	72,700				177	75	12,850	5,460	920	390	1,100	2,600	760
1. Minor Southern Pacific	22,800			.325	196	71	4,470	1,620	1,000	370	980	2,700	720
Soledad, Cal. (Arroyo Seco)	215	284	33.0	.793	222	26							
Santa Maria, Cal. (Santa Maria River)	1,000	2,412	1,302.0		204	110							
Santa Barbara, Cal. (Santa Ynez River)	207	714	64.0	.495	348	31							

[a] Figures are based upon assumption that unit denudation above Ogdensburg is the same for the United States and Canada.
[b] Suspended matter probably far too low.
[c] Analyses cover only portion of year. Results appear too high for an average.

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Detailed estimates—Continued.

Drainage basin.	Physical and chemical data.				Estimated denudation.								
	Area (square miles).	Solids (parts per million).		Run-off (second-feet per square mile).	Tons of solids per square mile per year.		Thousand tons of solids per year.		Millionths of an inch per year.		Years required for 1 inch.		
		Dissolved.	Suspended.		Dissolved.	Suspended.	Dissolved.	Suspended.	Dissolved.	Suspended.	Dissolved.	Suspended.	Total.
VIII. Southern Pacific—Continued.													
1. Minor Southern Pacific—Continued.													
Calabasas, Cal. (Malibu Creek)	97	717	61.0	.375	265	23							
Mentone, Cal. (Santa Ana River)	182	139	53.0	.409	56	21							
Pala, Cal. (San Luis Rey)	318	321	142.0	.352	111	49							
2. San Francisco Bay	49,900				168	77	8,380	3,840	880	400	1,100	2,500	780
Sacramento River	31,400			1.45	172	86							
Sacramento, Cal.	29,500	121	60.0	1.45	172	86							
San Joaquin River [a]	16,500			1.02	162	60							
Lathrop, Cal.	12,500	161	60.0	1.02	162	60							
IX. Northern Pacific	[b] 270,000				100	20	27,000	5,400	520	100	1,900	9,000	1,600
X. Great Basin	[b] 223,000				90	50	20,070	11,150	470	260	2,100	3,800	1,400
XI. Hudson Bay (in United States)	62,000				28	21	1,740	1,300	150	110	6,800	9,100	3,900
Red River of the North—													
Total area in United States	50,000				28	21	1,400	1,050	150	110	6,800	9,100	3,900
Grand Forks, N. Dak.	25,000	[c] 200	[c] 150.0	.141	28	21							

[a] Excluding Tulare Lake.

[b] Analytical data extremely meager.

[c] Estimated from four analyses.

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DEVELOPED WATER POWERS.

Compiled by the Bureau of the Census, under the direction of W. M. STEUART, Chief Statistician for Manufactures.
Discussion by M. O. LEIGHTON, Chief Hydrographer, U. S. Geological Survey.

A special census of the developed water powers of the United States has been made by the Bureau of the Census for the specific purposes of the conservation report. Previous inquiries of the same kind, made by this bureau, afforded a record of the names and locations of practically all the water-power developments that had taken place up to the dates thereof, and this record was used as the basis for the new census. Information concerning the developments that have been made since the date of the last census was procured through the Geological Survey, Forest Service, Bureau of Corporations, Post-Office Department, and many other agencies, both state and national. Special inquiry blanks were sent to all, including those that had figured in past censuses.

In making the new census it was necessary to procure the data in large measure by mail, and therefore it was necessary to simplify the inquiry and to secure only the facts absolutely necessary to a comprehensive summary of the developed water powers. The inquiry blank used for this purpose is reproduced below:

[Return this card to the Department of Commerce and Labor, Bureau of the Census, Washington, D. C.]

WATER POWER, 1908.

This office is engaged in the preparation of a report on the developed and undeveloped water power of the United States. If you use water power, please answer the following inquiries. If you do not use water power, please so state, and give the names and addresses of any power plants in your neighborhood. The card should be returned in the inclosed official envelope.

Name _____
Post-office _____ State _____
Location of plant: County _____ State _____
Name of river or stream on which plant is located _____
Number of water wheels _____ Maximum horsepower _____
Horsepower actually developed during low-water season _____
Additional power that may be developed at same point on the same river or stream, horsepower _____
Auxiliary steam power used in same plant, horsepower _____
Character of industry _____
(Give name of principal product.)
Give names and addresses of other power plants in your neighborhood _____

The character of the returns and the proportion of replies received indicate that the census is fairly complete. It is known that a greater

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number of the plants not accounted for in this census are of small capacity. There is, of course, some deficiency in the total; but it is believed that this is compensated by the general tendency among water-power owners to return statements based on actual wheel capacity installed rather than actual minimum power developed during the extreme low-water season. In all wheel installation it is the practice to develop above the minimum flow, and it follows that in the majority of power plants there must be a tendency to overstate the power actually developed during the lowest water. The final figures represent what is believed by those most conversant with the situation to be a reasonably accurate summary of the water power now developed in the country.

The material procured from the census has been arranged by drainage areas and combined into grand divisions, according to the plan followed in the report on undeveloped water power.

Accompanying Table No. 1 gives a general summary of the horsepower developed in the United States and the number of wheels used for such development. It will be noted that this table gives results according to States as well as according to grand divisions.

Some interesting facts are shown. The total development in the country is 5,356,680 horsepower over 52,827 wheels, or an average development per wheel of about 100 horsepower. In the Northern Atlantic division there has been a greater water-power development than in any other, the total installation being 1,746,303 horsepower. The only other division that approaches the Northern Atlantic in development is that covering the drainage area of the St. Lawrence, including the Great Lakes, where there has been a development of 1,018,283 horsepower. The great power development in the Northern Atlantic division may largely be explained by the fact that the use of water power therein began at an earlier period than in any other divison. New England and the Middle Atlantic States are and have been essentially manufacturing in character, and water-power development has followed as a matter of course. It is also true that the presence of good powers in large numbers in this region has encouraged such development.

Comparisons of wheel capacities installed in various parts of the country are interesting. While the total figures show that the average power per wheel is 100 horsepower, the units in the various districts vary as follows:

Division.	Unit capacity horsepower per wheel.	Division.	Unit capacity horsepower per wheel.
Northern Atlantic	80	St. Lawrence	148
Southern Atlantic	77	Colorado River	261
Eastern Gulf of Mexico	42	Southern Pacific	515
Western Gulf of Mexico	47	Northern Pacific	295
Eastern Mississippi	60	Interior drainage	328
Western Mississippi	139	Arctic Ocean	125

The large number and small unit capacity of wheels in the eastern part of the country compared with the smaller number and larger capacity in the western portions, including, especially, the rivers draining from the Rocky Mountains and the Sierras, may be ex-

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plained: First, by the fact that in the eastern and central portions of the country the power privileges are of smaller capacity; and second, by the fact that in the eastern portions of the country a large number of the powers were installed at an early date, when it was the rule to establish small units. More recent practice has involved the establishment of larger units, and as the western installations are all recent, this practice, taken together with the existence of larger power privileges, gives the result that might be expected from a general survey of the situation.

Table 1 shows that New York State has the largest water-power development, the total being 885,862 horsepower. It is proper to add that the Niagara powers on the New York side assist largely in making up this figure. The second State in water-power development is California, the total being 466,774 horsepower, over 1,070 wheels, or a unit installation of about 436 horsepower. Water-power development in California is comparatively recent. The third State is Maine, with 343,096 horsepower, over 2,797 wheels, or an average of 123 horsepower per wheel. As the use of water power in this State is comparatively ancient, the contrast in unit capacity between it and California is significant.

Among the other interesting points is the fact that, although, as shown by the report on undeveloped water power, the Northern Pacific division can be made to furnish about one-third of the total minimum horsepower of the country, there is at the present time a development of only 450,000 horsepower, which indicates clearly that the most fertile field for power development remaining in the United States is this northwestern country.

Table 2 gives the installations by districts and drainage areas, special comment concerning which is unnecessary.

Census returns show that, out of a total of 31,537 powers reported, 602 are of capacity of 1,000 horsepower or more. Recent progress in water-power development has been marked by great installations. In former years the aggregate water power utilized in the country was made up largely of small units, which, while useful for local purposes and worthy of development, are not relatively important in the great question of power economics. The following summary gives the distribution of the powers of 1,000 horsepower and greater capacity, and it shows clearly that what was formerly believed to be an uncommonly great installation must now be considered a comparatively small feature.

Capacity distribution of powers of 1,000 horsepower and more.

1,000 to 5,000	459
5,000 to 10,000	65
10,000 to 15,000	27
15,000 to 20,000	13
20,000 to 25,000	17
25,000 to 40,000	11
40,000 to 60,000	4
60,000 to 100,000	3
100,000 and over	3
Total	602

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Number of water powers by States and Territories, 1908.

United States	31,537	Missouri	277
Alabama	1,382	Montana	94
Alaska	31	Nebraska	157
Arizona	29	Nevada	32
Arkansas	203	New Hampshire	876
California	559	New Jersey	560
Colorado	230	New Mexico	48
Connecticut	893	New York	3,148
Delaware	119	North Carolina	2,614
District of Columbia	1	North Dakota	9
Florida	166	Ohio	480
Georgia	1,596	Oklahoma	25
Idaho	199	Oregon	345
Illinois	155	Pennsylvania	3,721
Indiana	222	Rhode Island	191
Iowa	207	South Carolina	846
Kansas	118	South Dakota	45
Kentucky	691	Tennessee	1,793
Louisiana	64	Texas	147
Maine	1,222	Utah	200
Maryland	496	Vermont	1,148
Massachusetts	1,370	Virginia	2,243
Michigan	657	Washington	322
Minnesota	195	West Virginia	525
Mississippi	273	Wisconsin	580
		Wyoming	33

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TABLE 1.—*General summary—Drainage basins by States.*

States.	Northern Atlantic.		Southern Atlantic.		Gulf of Mexico.				Mississippi River.			
					Eastern.		Western.		Tributaries from the east.		Tributaries from the west.	
	Wheels.	Horsepower.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
United States	21,864	1,746,303	5,938	459,652	3,342	139,758	258	12,071	8,959	537,080	2,385	331,739
Alabama					1,539	56,603			265	105,091		
Alaska												
Arizona												
Arkansas											255	5,868
California												
Colorado							13	937			146	26,279
Connecticut	1,546	118,145										
Delaware	277	7,976										
District of Columbia	6	1,000										
Florida			13	420	194	4,119						
Georgia			854	90,036	1,307	74,255			153	2,296		
Idaho												
Illinois									413	50,116		
Indiana									298	11,525		
Iowa											461	17,304
Kansas											184	18,606
Kentucky									834	14,156		
Louisiana					35	615	22	296			22	273
Maine	2,797	343,096										
Maryland	679	21,403							15	312		
Massachusetts	2,749	260,182										
Michigan												
Minnesota									100	15,925	361	82,007
Mississippi					267	4,166			69	3,756		
Missouri											397	10,107
Montana											162	140,494
Nebraska											227	12,792
Nevada												
New Hampshire	1,799	183,167										
New Jersey	902	38,011										
New Mexico							32	939			13	251
New York	3,046	304,003							87	3,167		
North Carolina			3,049	140,918					926	21,366		
North Dakota												
Ohio									682	26,291		

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TABLE 1.—*General summary—Drainage basins by States*—Continued.

States.	Northern Atlantic.		Southern Atlantic.		Gulf of Mexico.				Mississippi River.			
					Eastern.		Western.		Tributaries from the east.		Tributaries from the west.	
	Wheels.	Horsepower.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
Oklahoma											29	2,994
Oregon												
Pennsylvania	5,046	273,426							530	16,849		
Rhode Island	387	37,165										
South Carolina			1,301	207,242								
South Dakota											68	11,112
Tennessee									2,160	95,060		
Texas							190	9,899			5	67
Utah												
Vermont	1,047	90,672										
Virginia	1,440	59,129	721	21,036					850	19,958		
Washington												
West Virginia	143	8,928							529	11,572		
Wisconsin									1,048	139,640		
Wyoming											55	3,585

States.	St. Lawrence River.		Colorado River.		Southern Pacific.		Northern Pacific.		Interior drainage.		Arctic Ocean.		Total.	
	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
United States	6,896	1,018,283	285	74,428	822	423,707	1,659	[a] 489,454	353	115,944	66	8,261	52,827	5,356,680
Alabama													1,804	161,694
Alaska							106	17,289					106	17,289
Arizona			37	16,855									37	16,855
Arkansas													255	5,868
California					820	423,597	176	25,440	74	17,737			1,070	466,774
Colorado			194	51,662									353	78,878
Connecticut													1,546	118,145
Delaware													277	7,976

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District of Columbia													6	1,000
Florida													207	4,539
Georgia													2,314	166,587
Idaho							261	60,533	24	18,210			285	78,743
Illinois													413	50,116
Indiana	197	17,628											495	29,153
Iowa													461	17,304
Kansas													184	18,606
Kentucky													834	14,156
Louisiana													79	1,184
Maine													2,797	343,096
Maryland													694	21,715
Massachusetts													2,749	260,182
Michigan	1,498	205,019											1,498	205,019
Minnesota	20	46,800									50	7,648	531	152,380
Mississippi													336	7,922
Missouri													397	10,107
Montana							42	7,558					204	148,052
Nebraska													227	12,792
Nevada			1	3			7	252	31	20,322			39	20,577
New Hampshire													1,799	183,167
New Jersey													902	38,011
New Mexico			10	1,120									56	2,310
New York	3,380	578,692											6,513	885,862
North Carolina													3,975	162,284
North Dakota											16	613	16	613
Ohio	191	8,549											873	34,840
Oklahoma													29	2,994
Oregon					2	110	586	231,203	2	66			590	231,379
Pennsylvania	20	715											5,596	290,990
Rhode Island													387	37,165
South Carolina													1,301	207,242
South Dakota													68	11,112
Tennessee													2,160	95,060
Texas													195	9,966
Utah			38	4,656					222	59,609			260	64,265
Vermont	971	79,604											2,018	170,276
Virginia													3,011	100,123
Washington							475	147,041					475	147,041
West Virginia													672	20,500
Wisconsin	619	81,276											1,667	220,916
Wyoming			5	132			6	138					66	3,855

a Includes Alaska.

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TABLE 2.—*Drainage basins in the United States.*

I. NORTHERN ATLANTIC.

Drainage basins.	Maine.		New Hampshire.		Vermont.		Massachusetts.		Connecticut.		Rhode Island.		New York.	
	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
	2,797	343,096	1,799	183,167	1,047	90,672	2,749	260,182	1,546	118,145	387	37,165	3,046	304,003
St. Johns River	147	13,681												
St. Croix River	89	20,500												
Penobscot River	518	70,454												
Kennebec River	659	63,936												
Androscoggin River	590	101,355	93	22,100										
Presumpscot River	179	20,569												
Saco River	169	22,302	68	3,030										
Merrimac River			877	90,082			589	71,251						
Connecticut River			574	50,977	929	85,512	1,117	123,309	490	33,101				
Blackstone River							182	14,111			156	17,324		
Thames River							88	8,499	478	45,214	1	25		
Housatonic River							138	14,206	364	31,685			17	459
Hudson River					118	5,160	54	5,245					2,083	275,125
Passaic River													30	775
Raritan River														
Delaware River													208	5,924
Susquehanna River													645	20,187
Potomac River														
James River														
Minor streams (Chesapeake Bay)														
Minor streams (northern Atlantic)	446	30,299	187	16,978			581	23,561	214	8,145	230	19,816	63	1,533

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Drainage basins.	New Jersey.		Delaware.		Pennsylvania.		Maryland.		Virginia.		West Virginia.		District of Columbia.		Total.	
	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
	902	38,011	277	7,976	5,046	278,426	679	21,403	1,440	59,129	143	8,928	6	1,000	21,864	1,746,303
St. Johns River															147	13,681
St. Croix River															89	20,500
Penobscot River															518	70,454
Kennebec River															659	63,936
Androscoggin River															683	123,455
Presumpscot River															179	20,569
Saco River															237	25,332
Merrimac River															1,466	161,333
Connecticut River															3,110	292,899
Blackstone River															338	31,435
Thames River															567	53,738
Housatonic River															519	46,350
Hudson River	17	680													2,272	286,210
Passaic River	179	12,805													209	13,580
Raritan River	204	6,309													204	6,309
Delaware River	427	15,327	167	5,314	1,616	47,649									2,418	74,214
Susquehanna River					3,233	222,530	71	2,217							3,949	244,934
Potomac River					197	3,247	260	4,766	462	11,457	142	8,920	6	1,000	1,067	29,390
James River									607	40,165	1	8			608	40,173
Minor streams (Chesapeake Bay)			35	901			346	14,389	363	7,429					744	22,719
Minor streams (northern Atlantic)	75	2,890	75	1,761			2	31	8	78					1,881	105,092

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TABLE 2.—*Drainage basins in the United States*—Continued.

II. SOUTHERN ATLANTIC.

Drainage basins.	Virginia.		South Carolina.		North Carolina.		Georgia.		Florida.		Total.	
	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
	721	21,036	1,301	207,242	3,049	140,918	854	90,036	13	420	5,938	459,652
Chowan River	113	2,381	.....	.....	64	1,147	.....	.....	.....	.....	177	3,528
Roanoke River	607	18,647	.....	.....	198	17,419	.....	.....	.....	.....	805	36,066
Tar River	.....	.....	.....	.....	166	6,431	.....	.....	.....	.....	166	6,431
Neuse River	.....	.....	.....	.....	317	11,365	.....	.....	.....	.....	317	11,365
Cape Fear River	.....	.....	.....	.....	673	27,539	.....	.....	.....	.....	673	27,539
Pedee (Yadkin) River	.....	.....	228	7,867	1,124	50,432	.....	.....	.....	.....	1,352	58,299
Santee River	.....	.....	573	179,706	478	26,028	.....	.....	.....	.....	1,051	205,736
Savannah River	.....	.....	294	16,178	.....	.....	245	43,357	.....	.....	539	59,535
Ogeechee River	.....	.....	.....	.....	.....	.....	88	1,965	.....	.....	88	1,965
Altamaha River	.....	.....	.....	.....	.....	.....	506	44,531	.....	.....	506	44,531
Minor streams (southern Atlantic)	1	8	206	3,489	29	557	15	183	13	420	264	4,657

III. EASTERN GULF OF MEXICO.

Drainage basins.	Florida.		Georgia.		Alabama.		Mississippi.		Louisiana.		Total.	
	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
	194	4,119	1,307	74,255	1,539	56,603	267	4,166	35	615	3,342	139,758
Suwanee River	16	265	29	962	.....	.....	.....	.....	.....	.....	45	1,227
Apalachicola River	36	565	784	62,991	114	7,717	.....	.....	.....	.....	934	71,273
Mobile River:												
Tombigbee River	.....	.....	.....	.....	340	5,193	79	1,097	.....	.....	419	6,290
Alabama River	.....	.....	464	9,869	799	37,892	.....	.....	.....	.....	1,263	47,761
Pearl River	.....	.....	.....	.....	.....	.....	86	1,532	18	312	104	1,844
Minor streams (eastern Gulf of Mexico)	142	3,289	30	433	286	5,801	102	1,537	17	303	577	11,363

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IV. WESTERN GULF OF MEXICO.

Drainage basins.	Louisiana.		Texas.		New Mexico.		Colorado.		Total.	
	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
	22	296	190	9,899	33	939	13	937	258	12,071
Sabine River	11	126	24	263					35	389
Neches River			35	538					35	538
Trinity River			12	279					12	279
Brazos River			13	448					13	448
Colorado River (of Texas)			25	1,503					25	1,503
Guadalupe River			69	6,447					69	6,447
San Antonio River			6	215					6	215
Nueces River			3	36					3	36
Rio Grande			1	102	16	370	13	937	30	1,409
Pecos River			2	68	17	569			19	637
Minor streams (western Gulf of Mexico)	11	170							11	170

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TABLE 2.—*Drainage basins in the United States*—Continued.

V. MISSISSIPPI RIVER (TRIBUTARIES FROM EAST).

Drainage basins.	Mississippi.		Alabama.		Georgia.		Tennessee.		North Carolina.		Virginia.		West Virginia.		Kentucky.	
	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.
	69	3,756	265	105,091	153	2,296	2,160	95,060	926	21,366	850	19,958	529	11,572	834	14,156
Yazoo River																
Minor eastern tributaries, lower Mississippi River	61	709					62	796							4	67
Ohio River:																
Tennessee River	8	3,047	265	105,091	153	2,296	1,691	85,548	710	19,260	378	6,214			8	103
Cumberland River							397	8,576							284	4,431
Green River							10	140							205	3,634
Kentucky River															158	2,916
Licking River															52	928
Big Sandy River											20	261	20	320	91	924
Kanawha River									216	2,106	452	13,483	282	7,023		
Monongahela River													129	2,324		
Youghiogheny River													3	50		
Minor southern tributaries													95	1,855	32	1,153
Allegheny River																
Beaver River																
Muskingum River																
Scioto River																
Great Miami River																
Wabash River																
Minor northern tributaries																
Illinois River																
Rock River																
Wisconsin River																
Chippewa River																
St. Croix River																
Minor eastern tributaries, upper Mississippi River																

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Drainage basins.	Pennsylvania.		Ohio.		Indiana.		Illinois.		Wisconsin.		Minnesota.		New York.		Maryland.		Total for drainage basins.	
	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.
	530	16,849	682	26,291	298	11,525	413	50,116	1,048	139,640	100	15,925	87	3,167	15	312	8,959	537,080
Yazoo River																		
Minor eastern tributaries, lower Mississippi River																	127	1,572
Ohio River:																		
Tennessee River																	3,213	221,559
Cumberland River																	681	13,007
Green River																	215	3,774
Kentucky River																	158	2,916
Licking River																	52	928
Big Sandy River																	131	1,505
Kanawha River																	950	22,612
Monongahela River	18	262															147	2,586
Youghiogheny River	56	1,205													15	312	74	1,567
Minor southern tributaries	3	70															130	3,078
Allegheny River	331	8,146											87	3,167			418	11,313
Beaver River	121	7,154	44	2,320													165	9,474
Muskingum River			204	8,880													204	8,880
Scioto River			69	2,045													69	2,045
Great Miami River			187	8,245	27	1,224											214	9,469
Wabash River					238	9,993	4	72									242	9,665
Minor northern tributaries	1	12	178	4,801	24	465	6	118									209	5,396
Illinois River					9	243	222	36,162	29	893							260	37,298
Rock River							167	13,214	210	10,967							377	24,181
Wisconsin River									476	74,491							476	74,491
Chippewa River									157	24,976							157	24,976
St. Croix River									58	11,025	13	1,750					71	12,775
Minor eastern tributaries, upper Mississippi River							14	550	118	17,288	87	14,175					219	32,013

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TABLE 2.—*Drainage basins in the United States*—Continued.

VI. MISSISSIPPI RIVER (TRIBUTARIES FROM THE WEST).

Drainage basins.	Louisiana.		Arkansas.		Texas.		Oklahoma.		New Mexico.		Colorado.		Kansas.		Missouri.	
	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
	22	273	255	5,868	5	67	29	2,994	13	251	146	26,279	184	18,606	397	10,107
Minnesota River																
Wapsipinicon River																
Des Moines River																
Missouri River:																
Big Sioux River																
James River																
Milk River																
Marias River																
Jefferson River																
Madison River																
Gallatin River																
Minor northern tributaries															38	938
Musselshell River																
Yellowstone River																
Little Missouri River																
Cheyenne River																
White River																
Niobrara River																
Platte River											126	21,803				
Kansas River											1	75	122	10,192		
Osage River													1	18	71	1,448
Minor southern tributaries													1	15	31	502
Arkansas River			74	1,100							19	4,401	22	1,205	194	5,874
Cimarron River:																
Canadian River							7	291	13	251						
Minor tributaries			108	3,797			4	160					38	7,176		
Red River	22	273	73	971	5	67	18	2,543								
Minor western tributaries Mississippi River															63	1,345

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Drainage basins.	Iowa.		Nebraska.		Wyoming.		Montana.		South Dakota.		Minnesota.		Total.	
	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
	461	17,304	227	12,792	55	3,585	162	140,494	68	11,112	361	82,007	2,385	331,739
Minnesota River											40	1,712	40	1,712
Wapsipinicon River	54	1,655											54	1,655
Des Moines River	27	1,360									3	198	30	1,558
Missouri River:														
Big Sioux River	8	261							15	3,115			23	3,376
James River									20	411			20	411
Milk River														
Marias River														
Jefferson River							38	20,619					38	20,619
Madison River							13	17,336					13	17,336
Gallatin River							6	405					6	405
Minor northern tributaries	62	2,274					44	67,215	11	231			155	70,658
Musselshell River														
Yellowstone River					19	1,389	26	6,224					45	7,613
Little Missouri River														
Cheyenne River					20	331			22	7,355			42	7,686
White River			1	30									1	30
Niobrara River			30	950									30	950
Platte River			74	5,572	16	1,865							216	29,240
Kansas River			89	5,156									212	15,423
Osage River													72	1,466
Minor southern tributaries			33	1,084			35	28,695					100	30,296
Arkansas River													309	12,580
Cimarron River:														
Canadian River													20	542
Minor tributaries													150	11,133
Red River													118	3,854
Minor western tributaries Mississippi River	310	11,754									318	80,097	691	93,196

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TABLE 2.—*Drainage basins in the United States*—Continued.

VII. ST. LAWRENCE RIVER.

Drainage basins.	Minnesota.		Wisconsin.		Michigan.		Indiana.		Ohio.		Pennsylvania.		New York.		Vermont.		Total.	
	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.
	20	46,800	619	81,276	1,498	205,019	197	17,628	191	8,549	20	715	3,380	578,692	971	79,604	6,896	1,018,283
Lake Superior	20	46,800	6	2,227	73	34,775											99	83,802
Lake Michigan			613	79,049	963	145,179	172	16,463									1,748	240,691
Lake Huron					213	13,878											213	13,878
St. Clair River					85	3,331											85	3,331
Lake Erie					164	7,856	25	1,165	191	8,549	17	593	129	4,838			526	23,001
Niagara River													103	191,426			103	191,426
Lake Ontario											3	122	2,025	209,368			2,028	209,490
Lake Champlain (Richelieu River)													373	50,345	971	79,604	1,344	129,949
Minor St. Lawrence tributaries													750	122,715			750	122,715

VIII. COLORADO RIVER.

Drainage basins.	Arizona.		New Mexico.		Colorado.		Wyoming.		Utah.		Nevada.		Total.	
	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.
	37	16,855	10	1,120	194	51,662	5	132	38	4,656	1	3	285	74,428
Gila River	26	16,611	7	995									33	17,606
Williams River	1	9											1	9
Little Colorado River	8	185											8	185
San Juan River			3	125	45	18,260							48	18,385
Grand River					145	32,132			1	6			146	32,138
Green River					4	1,270	5	132	17	3,378			26	4,781
Fremont River									4	93			4	90
Virgin River									9	188	1	3	10	193
Minor tributaries	2	50							7	991			9	1,041

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IX. SOUTHERN PACIFIC.

Drainage basins.	California.		Oregon.		Total.	
	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.
	820	423,597	2	110	822	423,707
Minor streams	74	50,183			74	50,183
San Francisco Bay	11	6,455			11	6,455
Sacramento River	576	280,735	2	110	578	280,845
San Joaquin River	159	86,224			159	86,224

X. NORTHERN PACIFIC.

Drainage basins.	Oregon.		Idaho.		Wyoming.		Montana.		Washington.		California.		Nevada.		Total.	
	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.
	586	231,203	261	60,533	6	138	42	7,558	475	147,041	176	25,440	7	252	a 1,553	a 472,165
Columbia River:																
Willamette River	299	92,531													299	92,531
Des Chutes River	17	60,832													17	60,832
John Day River	24	22,083													24	22,083
Snake River	55	35,771	186	36,402	6	138			28	4,728			7	252	282	77,291
Spokane River			70	23,176					33	14,473					103	37,649
Pend Oreille (Clark Fork)			2	600			37	6,838	7	237					46	7,675
Yakima River									52	8,838					52	8,838
Minor tributaries	55	10,176							186	33,099					241	43,275
Kootenai River			3	355			5	720							8	1,075
Puget Sound									139	84,270					139	84,270
Minor streams, northern Pacific	136	9,810							30	1,396	176	25,440			342	36,646

a Exclusive of Alaska, with 106 wheels, of 17,289 horsepower.

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TABLE 2.—*Drainage basins in the United States*—Continued.

XI. GREAT BASIN.

Drainage basins.	Utah.		Nevada.		California.		Oregon.		Idaho.		Total.	
	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
	222	59,609	31	270,322	74	17,737	2	66	24	18,210	353	115,944
Wasatch Mountains drainage	222	59,609							24	18,210	246	77,819
Humboldt River			31	20,322			2	66			33	20,388
Sierra Nevada drainage					74	17,737					74	17,737
Minor streams in Great Basin												

XII. HUDSON BAY.

Drainage basins.	North Dakota.		Minnesota.		Total.	
	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.
	16	613	50	7,648	66	8,261
Red River of the North	16	613	50	7,648	66	8,261
St. Marys River						

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UNDEVELOPED WATER POWERS.

By M. O. LEIGHTON,
Chief Hydrographer, United States Geological Survey.

The surveys and examinations necessary to a thorough and accurate report of the water-power resources of the United States have never been completed. In certain parts of the country the facts are sufficiently well known to make it possible to present a tolerably accurate statement. In other parts the information is fragmentary, and therefore power estimates must be considered approximate. Taken as a whole, however, the schedule here appended will be sufficient for the purposes for which it was prepared.

In order to present the information in a systematic way, the drainage areas of the United States have been united into groups according to geographic distribution. These group boundaries have been arbitrarily determined according to what seems to be the most convenient arrangement for the purposes of this report. The grouping is as follows: Atlantic Ocean, Pacific Ocean, Arctic Ocean, and interior drainage. These groups have been subdivided into 12 principal divisions, as follows: I. Northern Atlantic; II. Southern Atlantic; III. Eastern Gulf of Mexico; IV. Western Gulf of Mexico; V. Mississippi River (tributaries from the east); VI. Mississippi River (tributaries from the west); VII. St. Lawrence; VIII. Colorado River; IX. Southern Pacific; X. Northern Pacific; XI. Great Basin; XII. Hudson Bay.

SOURCES OF DATA.

The data used in this report have been obtained from the following sources:

The records of flow are mainly from the reports and files of the water-resources branch of the United States Geological Survey. As the period over which these records extend varies in length, a seven-year period, extending from 1900 to 1906, inclusive, was taken as a basis and all values of flow are the mean for these years.

The profiles and elevations have been obtained as follows:

(*a*) River surveys made by the United States Geological Survey, U. S. Army Engineer Corps, and others.

(*b*) Elevations as given by railroad and other levels.

(*c*) Dictionary of Altitudes, Bulletin No. 274, United States Geological Survey.

(*d*) United States Geological Survey topographic maps.

(*e*) Miscellaneous maps and reports of various State and other organizations.

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In the use of maps the following preferences have been given: (1) United States Geological Survey topographic sheets; (2) special detailed surveys; (3) General Land Office maps; (4) United States post-route maps; (5) Rand & McNally Atlas sheets

WATER POWER.

The schedule presented in this report gives the amount of available water power according to three classifications—(1) that which may be produced by the minimum flow; (2) the assumed maximum development; and (3) the additional power that may be recovered by developing the available storage capacity in the upland basins and using stored water to compensate the low-water periods. The data as a whole have been considered without reference to present practicability of development or present market. For the purposes of this report it has been assumed that all the power in the United States will some day be required. Such an interpretation is the logical one when natural resources are being considered. In other words, the schedule here presented must be interpreted for the future rather than for the present. The reader should not assume that all the power here shown is economically available to-day. Much of it, indeed, would be too costly in development to render it of commercial importance under the present conditions of market and the price of fuel power. The schedule shows therefore what will be the maximum possibilities in the day when our fuel shall have become so exhausted that the price thereof for production of power is prohibitive, and the people of the country shall be driven to the use of all the water power that can reasonably be produced by the streams.

Consideration has been given to all the conditions that determine the possibilities of power production on the various rivers of the country. Especially has the slope of the stream channels been scrutinized. Theoretically, of course, the energy developed by the various rivers is that produced by the total fall of the water from source to mouth, but it has not been assumed that, even under ideal conditions of market, all this power will ever be commercially available. The flatter portions of the river channels can never be profitably developed for power and they have not been included in the schedule. The rivers have been divided into sections of varying length, determined by channel slope, and the fall and flow of each section have been obtained from the best available sources of information. The records of stream flow collected by the water-resources branch of the Geological Survey have almost uniformly been the only available resort, although acknowledgments should be made to the state water-supply commissions of New York and Pennsylvania; the state engineers of New York, Colorado, California, Oregon, and Nebraska; the territorial engineer of New Mexico; the state geological surveys of Maine, New Jersey, North Carolina, Virginia, Georgia, and Wisconsin; and various other bodies and individuals, public and private, who in the past have maintained measurements in cooperation with the United States Geological Survey or independently. Use has also been made of certain river gage records of the United States Weather Bureau and of the Corps of Engineers, U. S. Army.

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In determining the flow for the various sections the data of flow per square mile, procured from the sources above enumerated, have been applied. The drainage areas above the upper and the lower limits of each section have been determined and a mean taken for the whole section. This has been used as a factor along with the flow per square mile in determining the minimum flow for that section. This figure, together with 90 per cent of the total fall from head to foot, has been used to determine theoretical horsepowers, according to the usual formulas. It is obvious that in practice the entire fall along any stretch of river or at any power privilege can not be effectively utilized. In few places can even 90 per cent be utilized at the present time; but, inasmuch as these figures are supposed to cover future as well as present practice, and inasmuch as it may reasonably be assumed that future practice in water-power installation will improve, it is believed that 90 per cent of the fall along any particular power privilege or section may eventually be realized.

The results of calculations of theoretical power on 90 per cent total fall have been reduced 10 per cent to allow for inefficiency of wheels. It is recognized that 90 per cent efficiency is too high to be used in calculations of power at the present time, 75 or 80 per cent being the usual installation maximum. Here again, however, we are computing for future conditions, as well as present ones, and it may confidently be expected that, with the improvement of turbines, a greater percentage of the theoretical power will be realized on the shaft and improvements will before long render possible a 90 per cent efficiency.

In determining the minimum horsepower, the minimum flow for the lowest two consecutive seven-day periods in each year was determined and the mean of these values for the period of record was taken as the minimum flow. It is obvious that this is somewhat higher than the absolute minimum, but the latter is usually of so short duration that it does not equal the practicable minimum that may profitably be installed.

The assumed maximum economical development has been determined on the assumption that it is good commercial practice to develop wheel installation up to that amount the continuance of which can be assured during six months of the year, on the assumption that the deficiency in power during the remainder of the year can be profitably provided by the installation of fuel power plants as auxiliaries. In many parts of the country it has been shown conclusively that it is economical to develop up to that amount which can be had continuously during the highest four months of the year, and, while it is probable that there are parts of the country where the limit should be the highest eight or ten months, it is believed that the period used in these schedules is a very conservative average. The minimum weekly flow for each month of the year has been arranged according to magnitude, and the sixth value has been taken as the basis for estimating the power, the mean of these values for the record period in each case being that used in the computations.

An endeavor has been made to determine the maximum power that might be produced if the practicable maximum storage available on the drainage areas were established. Surveys on many of the basins make possible a fairly close statement; but, inasmuch as fully three-

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fourths of the country has not been surveyed in a manner suitable for this purpose, only rough estimates can be given for the entire area. There are two methods by which an approximate estimate of total power can be made.

The first is to consider the power on those drainage areas for which suitable surveys are available and to increase the amount by the equivalent of the proportion left unsurveyed. An examination of the facts will show that the amount obtained by this method will be too low. It is apparent from a review of the index map showing the areas covered by such surveys that a fairly large proportion, probably one-third, comprises country in which good reservoir sites are either lacking or are uncommon in occurrence. Such portions include large parts of the Dakotas, Nebraska, Kansas, Oklahoma, Texas, and Louisiana, together with great areas on the Atlantic and Pacific coastal plains. Therefore to increase the total available water power from storage that may be computed on surveyed portions by the ratio of total surveyed portions to the entire country would hardly do justice to the situation. Nevertheless, the figures are here presented.

It is found that the total power available in the surveyed portions, including storage, is about 53,000,000 horsepower. If this be considered as one-fourth, to correspond with the portion of the country surveyed, the total power of the country, with practical maximum storage will be about 212,000,000 horsepower.

The second method of computation involves consideration of the increase of power available from storage in the several portions of the country in which surveys have been made, and applying the ratio of increase to unsurveyed and similar country in those regions. The topographic surveys, while they cover only one-fourth of the total area of the country, have nevertheless been prosecuted in all sections, so that the storage data are applicable to all physiographic types that are comprised within the United States. Applying the information in this way, we obtain a grand total of 230,800,000 horsepower, which, it appears to the writer, is a more accurate figure than that obtained by the first method.

In any case, therefore, it may be assumed with confidence that, were all practicable storage sites utilized and the water properly applied, there might be established eventually in the country a total power installation of at least 200,000,000 horsepower and probably much more.

In the actual management of storage for water power or for any other water utilization the stored waters are released according as needed, and they must be distributed according to the condition of the river and the length of the dry season. Therefore, water from storage is required for a varying number of months, according to the climatological conditions governing the river discharge. Some assumption in this matter has been necessary, and it is believed from the experience that has been gained in the study of rivers throughout the country that it will be fair and conservative to assume that, if any given storage be considered as released uniformly during six months of the year, and the natural flow from the unconserved areas be considered as sufficient to maintain at least an equal flow during the remaining six months, the results will not depart too widely from the actual conditions as regards total power that may be achieved in

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practice, unless, indeed, they are too conservative. It is well known that on some rivers an economical use of stored water would involve a shorter period of total release than six months to insure the most uniform distribution of discharge. This would provide for a greater power development than the six months of distribution. Nevertheless, the latter has been considered a fair average, and has been used in the accompanying schedule.

Summing up the whole country according to the divisions thereof heretofore discussed, we obtain the general summary given below. Especial mention should be made of the fact that the results here given do not include the State of Pennsylvania, the figures for which had not been furnished up to the date of this report.

Estimate of stream flow and water power in the United States.

Principal drainages.	Drainage area in square miles.	Flow per annum in billion cubic feet.	Horsepower.	
			Minimum.	Assumed maximum development.
North Atlantic to Cape Henry, Va	159,879	8,942	1,712,050	[a]3,186,600
Southern Atlantic to Cape Sable, Fla	123,920	5,560	1,253,000	1,957,800
Eastern Gulf of Mexico to Mississippi River	142,220	6,867	559,000	963,000
Western Gulf of Mexico west of Vermilion River	[b]433,700	2,232	433,760	822,600
Mississippi River (tributaries from east)	333,600	12,360	2,619,590	[a]5,344,600
Mississippi River (tributaries from west, including Vermilion River)	905,200	9,580	3,948,970	7,085,000
St. Lawrence River to Canadian line	[c]299,720	8,583	6,682,480	8,090,000
Colorado River above Yuma, Ariz	225,000	521	2,918,500	5,546,000
Southern Pacific to Point Bonita, Cal	70,700	2,193	3,215,400	7,808,300
Northern Pacific	290,400	15,220	12,979,700	24,701,000
Great Basin	223,000	.....	518,000	801,000
Hudson Bay	62,150	614	75,800	212,600
Total	3,269,490	72,672	36,916,250	66,518,500

[a] Not including area in Pennsylvania.
[b] Includes Rio Grande in Mexico.
[c] Includes drainage in Canada.

It will be noted from the foregoing that the region furnishing by far the greatest water-power possibilities is the northern Pacific, which comprises essentially the basins of Columbia and Sacramento rivers, the power possibilities there being about one-third those of the whole United States.

The following schedules give in detail figures concerning run-off and potential water power over the various drainage areas included within the several districts:

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Estimate of stream flow and water power in the United States.

I. NORTHERN ATLANTIC.[a]

Stream.	States drained.	Drainage area (square miles).	Flow from area.				Horsepower.	
			Second-feet.	Second-feet per square mile.	Per annum.		Minimum.	Assumed maximum development.
					Depth in inches.	Billion cubic feet.		
St. Johns[b]	Maine	7,500	13,200	1.76	23.90	416	30,500	73,800
St. Croix	do	1,630	4,260	2.61	35.40	131	28,700	49,000
Penobscot	do	8,500	16,700	1.96	26.60	526	157,000	298,000
Kennebec	do	5,970	11,000	1.84	25.00	347	144,000	284,000
Androscoggin	Maine, New Hampshire	3,500	7,500	2.14	29.00	236	168,000	218,000
Presumpscot	Maine	600	1,010	1.68	22.80	32	(c)	(c)
Saco	Maine, New Hampshire	1,720	4,060	2.36	32.00	128	20,900	69,000
Merrimac	New Hampshire, Massachusetts	5,020	8,140	1.62	22.00	257	111,000	190,000
Connecticut	Vermont, New Hampshire, Massachusetts, Connecticut	11,100	22,100	1.99	27.00	697	230,000	491,000
Blackstone	Massachusetts, Rhode Island	(c)	.....	(c)	(c)	(c)	5,280	12,700
Thames	Massachusetts, Connecticut, Rhode Island	(c)	.....	(c)	(c)	(c)	14,400	28,600
Housatonic	New York, Massachusetts, Connecticut	1,980	4,300	2.17	29.40	136	43,100	66,200
Hudson	New York, Massachusetts, Vermont, New Jersey	13,400	25,400	1.90	25.80	802	298,000	473,000
Passaic	New York, New Jersey	949	2,060	2.17	29.40	65	10,000	22,000
Raritan	New Jersey	1,110	2,390	2.15	29.20	75	4,370	9,710
Delaware	New York, New Jersey, Pennsylvania, Delaware	13,100	25,800	1.97	26.70	814	.....	.....
Susquehanna	New York, Pennsylvania, Maryland	27,400	42,800	1.56	21.20	1,350	.....	.....
Potomac	Maryland, Virginia, West Virginia, Pennsylvania	14,300	17,300	1.21	16.40	545	176,000	462,000
James	Virginia	10,400	14,000	1.35	18.30	442	196,000	300,000
Minor streams (Chesapeake Bay)	Virginia, Maryland	12,800	20,300	1.59	21.60	640	43,300	82,000
Minor streams (northern Atlantic)	Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia.	18,900	41,200	2.18	29.60	1,300	31,500	57,600
Total		159,879	.....	.....	.....	8,942	.....	.....

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II. SOUTHERN ATLANTIC.[d]

Chowan	Virginia, North Carolina	5,000	7,000	1.40	19.00	221	5,100	10,100
Roanoke	do	9,740	12,200	1.25	17.00	385	205,000	343,000
Tar	North Carolina	4,360	5,500	1.26	17.10	174	4,000	8,000
Neuse	do	5,550	7,320	1.32	17.90	231	5,000	10,000
Cape Fear	do	9,030	11,100	1.23	16.70	350	40,000	80,000
Pedee (Yadkin)	North Carolina, South Carolina	10,600	16,900	1.60	21.70	533	222,000	334,000
Santee	do	14,800	24,500	1.66	22.50	772	400,000	590,000
Savannah	South Carolina, Georgia	11,100	17,500	1.58	21.40	552	290,000	438,000
Ogeechee	Georgia	5,140	6,530	1.27	17.20	206	4,300	10,700
Altamaha	do	14,100	17,700	1.26	17.10	558	57,600	94,000
Minor streams (southern Atlantic)	Virginia, North Carolina, South Carolina, Georgia, Florida	34,500	50,100	1.45	19.70	1,580	20,000	40,000
Total		123,920				5,560	1,253,000	1,957,800

III. EASTERN GULF OF MEXICO.[e]

Suwanee	Florida, Georgia	9,970	15,000	1.50	20.40	473	(f)	(f)
Apalachicola	Alabama, Georgia, Florida	18,800	30,300	1.61	21.80	956	204,000	326,000
Mobile	Alabama, Georgia, Mississippi	42,100	66,200	1.57	21.30	2,090		
Tombigbee	Alabama, Mississippi						50,000	100,000
Alabama	Alabama, Georgia						275,000	487,000
Pearl	Mississippi, Louisiana	8,650	12,300	1.42	19.30	388	(f)	(f)
Minor streams (eastern Gulf of Mexico)	Florida, Alabama, Mississippi, Louisiana	62,700	93,800	1.50	20.40	2,960	30,000	50,000
Total		142,220				6,867	559,000	963,000

IV. WESTERN GULF OF MEXICO.

Sabine	Texas, Louisiana	20,700	16,700	0.807	11.00	527	2,020	5,050
Trinity	Texas	17,700	9,370	.529	7.18	295	3,180	12,800
Brazos	Texas, New Mexico	48,800	9,760	.200	2.72	308	7,460	20,900
Colorado (Texas)	do	39,000	3,790	.097	1.32	120	28,100	55,700
Guadalupe	Texas	10,500	3,750	.357	4.84	118	36,000	43,400
Rio Grande[g]	Texas, New Mexico, Colorado	248,000	7,880	.032	.43	249	267,000	545,000
Pecos	Texas, New Mexico						55,000	87,800
Minor streams (western Gulf of Mexico)	Louisiana, Texas	49,000	19,500	.398	5.40	615	35,000	52,000
Total		433,700				2,232	433,760	822,650

[a] St. Johns to Cape Henry, Va.
[b] Drainage in United States only.
[c] Included in minor streams (northern Atlantic).
[d] Cape Henry, Va., to Cape Sable, Fla.
[e] Eastern Gulf of Mexico included between Cape Sable, Fla., and Mississippi River.
[f] Included in minor streams (eastern Gulf of Mexico.)
[g] Includes drainage area and flow in Mexico, but does not include power.

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Estimate of stream flow and water power in the United States—Continued.

V. MISSISSIPPI RIVER (TRIBUTARIES FROM THE EAST).

Stream.	States drained.	Drainage area (square miles).	Flow from area.				Horsepower.	
			Second-feet.	Second-feet per square mile.	Per annum.		Minimum.	Assumed maximum development.
					Depth in inches.	Billion cubic feet.		
Mississippi a		1,238,800	696,400	0.562	7.63	21,940	147,000	335,000
Eastern tributaries lower Mississippi, below Missouri River (exclusive of Ohio).		42,800	50,100	1.17	15.90	1,580	15,000	30,000
Ohio	Kentucky, Tennessee, Mississippi, Maryland, Pennsylvania, New York, Ohio, Illinois, Indiana, Alabama, Georgia, North Carolina, Virginia, West Virginia.	204,000	270,000	1.32	17.90	8,500	b 40,000	b 100,000
Tennessee	Kentucky, Tennessee, Mississippi, Alabama, Georgia, North Carolina, Virginia.						1,210,000	1,950,000
Cumberland	Kentucky, Tennessee, Virginia						76,800	159,000
Green	Kentucky, Tennessee						11,400	28,500
Kentucky	Kentucky						18,100	45,100
Licking	....do						5,360	13,400
Big Sandy	Kentucky, West Virginia, Virginia						21,700	57,600
Kanawha	West Virginia, Virginia, North Carolina						402,000	1,020,000
Monongahela	West Virginia, Pennsylvania						71,000	283,000
Minor southern tributaries (Ohio)	Tennessee, Kentucky, West Virginia, Pennsylvania						31,800	7,700
Allegheny	New York, Pennsylvania							
Beaver	Pennsylvania, Ohio						6,000	18,300
Muskingum	Ohio						16,500	53,100
Scioto	....do						3,630	17,200
Great Miami	Ohio, Indiana						28,700	74,600
Wabash	Indiana, Illinois						40,600	119,000
Minor northern tributaries (Ohio)	Illinois, Indiana, Ohio, Pennsylvania						10,000	41,200
Eastern tributaries, upper Mississippi, above Missouri River.	Illinois, Wisconsin, Minnesota	86,800	72,300	.833	11.30	2,280		
Illinois	Illinois						167,000	261,000
Rock	Illinois, Wisconsin						20,800	46,400
Wisconsin	Wisconsin						121,000	244,000
Chippewa	....do						99,000	238,000
St. Croix	Wisconsin, Minnesota						39,000	90,000
Minor eastern tributaries upper Mississippi above Missouri River).	Illinois, Wisconsin, Minnesota						17,200	43,200
Total		333,600				12,360		

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VI. MISSISSIPPI RIVER (TRIBUTARIES FROM THE WEST).

Western tributaries upper Mississippi (above Missouri River).	Minnesota, South Dakota, Iowa, Missouri	84,700	42,500	0.501	6.79	1,340		
Minnesota	Minnesota, South Dakota						17,300	46,600
Wapsipinicon	Iowa, Minnesota						4,380	10,700
Des Moines	do						59,800	222,000
Minor western tributaries upper Mississippi (above Missouri River).	Minnesota, South Dakota, Iowa, Missouri						132,000	275,000
Missouri [c]	Missouri, Louisiana, Minnesota, South Dakota, North Dakota, Montana, Wyoming, Colorado, Nebraska, Kansas.	527,000	[d] 94,000	.178	2.41	2,960	300,000	600,000
Big Sioux	Iowa, Minnesota, South Dakota						21,600	38,900
Milk	Montana						30,000	50,000
Marias	do						55,600	75,400
Jefferson	do						317,000	482,000
Madison	do						216,000	276,000
Gallatin	do						94,000	126,000
Minor northern tributaries (Missouri).	Missouri, Iowa, North Dakota, South Dakota, Montana						170,000	230,000
Musselshell	Montana						23,100	26,400
Yellowstone	Montana, Wyoming						1,430,000	2,170,000
Niobrara	South Dakota, Nebraska						122,000	140,000
Platte	Nebraska, Wyoming, Colorado						290,000	657,000
Kansas	Colorado, Nebraska, Kansas						105,000	287,000
Osage	Missouri, Kansas						7,890	19,000
Minor southern tributaries (Missouri).	Missouri, Kansas, Nebraska, South Dakota, North Dakota, Montana.						190,000	360,000
Western tributaries lower Mississippi, below Missouri River (exclusive of Arkansas).	Missouri, Arkansas, Texas, Oklahoma	116,000	102,000	.880	11.90	3,220		
Arkansas	Arkansas, Missouri, Kansas, Oklahoma, Colorado, New Mexico, Texas.	177,500	65,500	.369	5.00	2,060	110,000	182,000
Cimarron	Oklahoma, Kansas, New Mexico, Texas						11,500	44,000
Canadian	Oklahoma, Texas, New Mexico						83,900	348,000
Minor tributaries Arkansas	Arkansas, Missouri, Kansas, Oklahoma, Colorado, New Mexico, Texas.						67,000	145,000
Red	Louisiana, Arkansas, Texas, Oklahoma						48,900	148,000
Minor western tributaries, lower Mississippi below Missouri River.	Minnesota, Iowa, Missouri						42,000	126,000
Total		905,200				9,580	3,948,970	7,085,000

[a] Includes all drainage from the Mississippi to Vermilion River, inclusive.
[b] Horsepower at Louisville, Ky.
[c] Includes flow but exclusive of power in Canada.
[d] Mean annual discharge 1879–1890, inclusive, from Annual Report Chief of Engineers, 1891, p. 3826.

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Estimate of stream flow and water power in the United States—Continued.

VII. ST. LAWRENCE RIVER.[a]

Stream.	States drained.	Drainage area (square miles).	Flow from area.				Horsepower.	
			Second-feet.	Second-feet per square mile.	Per annum.		Minimum.	Assumed maximum development.
					Depth in inches.	Billion cubic feet.		
St. Lawrence at Ogdensburg, N. Y.		288,000	252,000	0.876	11.90	7,950		
Lake Superior	Minnesota, Wisconsin, Michigan	76,100	77,300	1.02	13.80		120,000	236,000
Lake Michigan	Michigan, Wisconsin, Illinois, Indiana	68,900	60,500	.878	11.90		246,000	356,000
Lake Huron	Michigan	68,900	60,000	.871	11.80		83,400	110,000
St. Clair	do	214,000	198,000	.926	12.60		3,380	6,760
Lake Erie	Ohio, Pennsylvania, New York, Michigan	[b] 40,800	22,000	[b] .540	7.33		28,000	62,300
Niagara	New York	255,000	220,000	.863	11.70		5,800,000	[c] 6,500,000
Lake Ontario[d]	do	33,000	32,100	.973	13.20		200,000	400,000
Lake Champlain (Richelieu River)	New York, Vermont	7,750	13,500	1.74	23.60	426	102,000	147,000
Minor St. Lawrence tributaries in New York below Ogdensburg.	New York	3,970	6,550	1.65	22.40	207	99,700	272,000
Total		299,720				8,583	6,682,480	[e] 8,090,060

VIII. COLORADO RIVER.

Colorado River above Yuma, Ariz.	Utah, Nevada, California, Arizona, New Mexico, Colorado, Wyoming.	225,000	16,500	0.0733	1.00	521	1,150,000	2,080,000
Gila	Arizona, New Mexico						72,500	241,000
Little Colorado	do						12,000	24,000
San Juan	Arizona, New Mexico, Utah, Colorado						149,000	341,000
Grand	Colorado, Utah						703,000	1,310,000
Green	Utah, Wyoming, Colorado						812,000	1,510,000
Minor tributaries	Arizona, New Mexico, Utah, Nevada, California						20,000	40,000
Total		225,000				521	2,918,500	5,546,000

IX. SOUTHERN PACIFIC.[f]

Minor streams (southern Pacific)	California	22,800	7,410	0.325	4.42	233	36,400	88,300
San Francisco Bay:								
Sacramento	California, Oregon	31,400	45,500	1.45	19.70	1,430	2,420,000	4,580,000
San Joaquin	California	[g] 16,500	[g] 16,800	[g] 1.02	[g] 13.80	[g] 530	[h] 759,000	[h] 3,140,000
Total		70,700				2,193	3,215,400	7,808,300

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X. NORTHERN PACIFIC.[e]

Columbia [f]	Oregon, Idaho, Wyoming, Montana, Washington, Nevada.	231,400	312,000	1.35	18.30	9,850	4,060,000	6,250,000
Willamette	Oregon						602,000	1,670,000
Des Chutes	do						953,000	1,920,000
John Day	do						79,700	158,000
Snake	Oregon, Washington, Idaho, Wyoming, Nevada						1,880,000	4,300,000
Spokane	Washington, Idaho						237,000	610,000
Pend Oreille (Clark Fork)	Idaho, Montana						1,530,000	2,620,000
Yakima	Washington						194,000	626,000
Kootenai	Montana, Idaho						207,000	357,000
Minor tributaries, Columbia	Oregon, Washington						718,000	1,230,000
Puget Sound	Washington	14,300	59,200	4.15	56.30	1,870	719,000	1,400,000
Minor streams, Northern Pacific	California, Oregon, Washington	44,700	111,000	2.48	33.60	3,500	1,800,000	3,560,000
Total		290,400				15,220	12,979,700	24,701,000

XI. GREAT BASIN.

Wasatch Mountains drainage	Utah, Wyoming, Idaho	44,300	7,620	0.172	2.33		92,000	149,000
Humboldt	Nevada	25,200	2,420	.096	1.30		20,000	30,000
Sierra Nevada drainage	California, Nevada, Oregon	[h] 55,900	[h] 18,900	[h] .338	[h] 4.58		[h] 396,000	[h] 607,000
Minor streams in Great Basin	California, Nevada, Utah, Oregon	97,600	10,100	1.03	1.40		10,000	15,000
Total		223,000					518,000	801,000

XII. HUDSON BAY.

Red (of the North) [l]	North Dakota, Minnesota	50,000	6,420	0.128	1.74	203	25,000	52,000
St. Mary	Montana	650	1,510	2.31	31.40	48	30,500	120,000
Rainy [m]	Minnesota	11,500	11,500	1.00	13.60	363	20,300	40,600
Total		62,150				614	75,800	212,600

[a] Values of drainage areas and discharge of the Great Lakes drainages derived chiefly from report of E. S. Wheeler, assistant engineer, U. S. Army. The discharge value is given for each of the Great Lakes as a unit from 1860 to 1892, and includes the run-off from both land and water surfaces. It shows the total discharge from both United States and Canadian territory.

[b] Includes Lake St. Clair.

[c] 3,500,000 horsepower at Niagara Falls on the basis of mean annual discharge.

[d] Includes Oswegatchie River and minor St. Lawrence tributaries above Ogdensburg, N. Y.

[e] Total horsepower of Niagara River and of tributaries to the Great Lakes in the United States.

[f] Southern Pacific included between Mexican line and Point Bonita, Cal.

[g] Exclusive of Tulare Lake drainage (see Sierra Nevada drainage).

[h] Includes Tulare Lake drainage.

[i] Northern Pacific included between Point Bonita, Cal., and Canadian line.

[j] Includes drainage area and flow in Canada, but does not include power.

[k] Does not include Tulare Lake drainage (see San Joaquin River).

[l] Includes drainage area and flow of Pembina and Mouse rivers in Canada, but does not include power.

[m] Drainage in United States only.

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Estimate of stream flow and water power in the United States—Continued.

GENERAL SUMMARY.

Principal drainages.	Drainage area (square miles).	Flow per annum (billion cubic feet).	Minimum.	Assumed maximum development.
Northern Atlantic to Cape Henry, Va	159,879	8,942	.....	.....
Southern Atlantic to Cape Sable, Fla	123,920	5,560	1,253,000	1,957,800
Eastern Gulf of Mexico to Mississippi River	142,220	6,867	559,000	963,000
Western Gulf of Mexico west of Vermilion River	[a] 433,700	[a] 2,232	433,760	822,650
Mississippi River (tributaries from east)	333,600	12,360	.....	.....
Mississippi River (tributaries from west, including Vermilion River)	905,200	9,580	3,948,970	7,085,000
St. Lawrence River to Canadian line	[b] 299,720	[b] 8,583	6,682,480	8,090,060
Colorado River above Yuma, Ariz	225,000	521	2,918,500	5,546,000
Southern Pacific to Point Bonita, Cal	70,700	2,193	3,215,400	7,808,300
Northern Pacific	290,400	15,220	12,979,700	24,701,000
Great Basin	223,000	.....	518,000	801,000
Hudson Bay	62,150	614	75,800	212,600
Total	3,269,489	72,672	.....	.....

[a] Includes Rio Grande in Mexico.

[b] Includes drainage in Canada.

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CONCENTRATION OF OWNERSHIP OF WATER POWERS.

By HERBERT KNOX SMITH,
Commissioner of Corporations.

The water-power situation has been greatly changed by recent improvements in electric-power transmission. Two-hundred-mile transmission is now regarded as commercially possible even in the cheaper coal areas. A two-hundred-mile radius opens an area of 120,000 square miles for the marketing of power from a given power plant.

A strong movement toward concentrating the control of water powers has accompanied this change. A very significant fact is that this concentration has taken place practically in the last five years. The chief existing concentrations are as follows:

(1) *General Electric*—being those power companies controlled by or having direct personal connections with the General Electric Company or its subsidiary corporations.

(2) *Westinghouse*—being those similarly connected with the Westinghouse Electric and Manufacturing Company, the Westinghouse Machine Company, and other Westinghouse interests.

(3) *Other concentrations* of water power which can not at present be identified with either of the first two.

Inter-company relations are easily concealed. Strictly judicial proof of such community of interests is rarely obtainable, nor is it necessary for practical purposes. It is sufficient to give, as herein, the significant evidential facts, leaving the obvious deductions to be made therefrom.

Therefore the General Electric and the Westinghouse concentrations are classified in the following groups:

(*a*) Those where a control by one or the other of these parent companies, directly or through subsidiary corporations, is admitted.

(*b*) Those where such control is inferred from substantial evidence (hereinafter summarized) with reasonable conclusiveness.

(*c*) Those where such control is at least partially indicated, though not proven, by the available evidence.

This report does not by any means assume to be a complete survey even of the present conditions of concentration. There may be many further affiliations as yet undiscovered. It is compiled, with two exceptions, from such data as the Bureau of Corporations had collected up to January 14, 1909, in the course of an investigation not yet completed.

The exact relations, if any, between these two groups (General Electric and Westinghouse) can not now be stated. General Electric and Westinghouse patents have been pooled since 1896, and certain individuals are interested in both General Electric and Westinghouse power companies.

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(1) GENERAL ELECTRIC.

The control of the General Electric Company is shown directly or through subsidiary corporations, or indicated by the appearance of the names of certain individuals unquestionably connected with the General Electric Company.

Such subsidiary corporations are:

United Electric Securities Company (Maine, 1890).

Electrical Securities Corporation (New York, 1904).

Electric Bond and Share Company (New York, 1905).

Such individuals most closely connected with General Electric Company water-power control are—

Sydney Z. Mitchell, vice-president and treasurer Electric Bond and Share Company (General Electric; see above), formerly with Stone & Webster, of Boston, to be mentioned later.

J. D. Mortimer, assistant secretary Electric Bond and Share Company (General Electric; see above) and director of American Gas and Electric Company.

C. N. Mason, vice-president Electrical Securities Corporation and of United Electric Securities Company (General Electric; see above).

H. L. Doherty, president American Gas and Electric Company, which in 1908 controlled at least 19 lighting and gas companies in various parts of the United States, and is, in turn, controlled by the Electric Bond and Share Company (General Electric; see above).

Other names which may be mentioned are—

C. A. Coffin, president General Electric Company.

A. W. Burchard, assistant to the president, General Electric Company, and director of American Gas and Electric Company (General Electric).

C. W. Wetmore, director of Electric Bond and Share Company.

Hinsdill Parsons, vice-president General Electric Company and director of Electric Bond and Share Company.

(*a*) Those water-power companies which are admittedly controlled by the General Electric Company or its subsidiary companies are—

Schenectady Power Company, New York, developments on the Hoosick River at Schaghticoke and Johnsonville, with a total development of 26,000 horsepower. This company is owned outright by the General Electric Company.

Carolina Power and Light Company, at Raleigh, N. C., with 4,000 horsepower installed on the Cape Fear River, and leasing power, in addition, on the Neuse River. The stock of this company is held by the Electric Bond and Share Company (General Electric) and voted by Mr. J. D. Mortimer. C. Elmer Smith, of Smith interests in Westinghouse group, is also interested.

Rockingham Power Company, in North Carolina, on the Yadkin River, in process of construction, with an installation to be of 32,000 horsepower. This company is financed by the Electrical Securities Corporation (General Electric), C. N. Mason of the latter being president. C. Elmer Smith (see above) is also interested.

Animas Power and Water Company, Colorado, on the Animas River, with 8,000 horsepower installed, is controlled through the Electric Bond and Share Company (General Electric).

Central Colorado Power Company, in Colorado, together with the Eastern Colorado Power Company, which it owns, has on the Grand

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River and Middle Boulder Creek installations to be of 63,000 horsepower and power sites in addition amounting to at least 25,000 horsepower. This company is being financed by W. P. Bonbright & Co., of New York City; Lee, Higginson & Co., of Boston, and the Electric Bond and Share Company (General Electric). Mr. H. L. Higginson, of Lee, Higginson & Co., is a director of the General Electric Company. Mr. S. Z. Mitchell, of the Electric Bond and Share Company, is a vice-president and member of the executive committee of this power company.

(*b*) Those water-power companies, the control of which by the General Electric Company or its subsidiary companies is reasonably inferred, are—

Montgomery Light and Water Power Company, near Montgomery, Ala., on the Tallapoosa River, with an installation of 6,000 horsepower. H. L. Doherty, president, American Gas and Electric Company (General Electric), is first vice-president of this company.

The Summit County Power Company, at Dillon, Colo., with an installation of 1,600 horsepower, has Mr. H. L. Doherty, of American Gas and Electric Company (General Electric), on its directorate.

Butte Electric and Power Company (Montana), a holding company for various subsidiary power companies, to wit: Montana Power Transmission Company, Madison River Power Company, Billings and Eastern Montana Power Company. These companies comprise six water-power developments in operation, with a total installation of 43,000 horsepower. The holding company (Butte Electric) is apparently controlled jointly by C. W. Wetmore, of Electric Bond and Share Company (General Electric), and C. A. Coffin, president of General Electric Company. P. E. Bisland, secretary, was formerly with Electrical Securities Corporation (General Electric).

Washington Water Power Company has three developments in Washington and Idaho, on the Spokane River, with a total installation of 61,000 horsepower. Mr. Hinsdill Parsons, vice-president of General Electric Company and Electric Bond and Share Company (General Electric), is on the directorate.

Great Western Power Company, in California, on the north fork of the Feather River in Butte County, with an installed capacity of 53,000 horsepower. On its directorate are Mr. A. W. Burchard, of the General Electric Company, and Mr. A. C. Bedford, of the Standard Oil Company. Mr. Bedford is also president of the Portland General Electric Company (see below).

(*c*) Control partially indicated.

There are also a number of other water-power companies, with a total of about 420,000 horsepower (including installations and power sites), whose connection with the General Electric Company is at least partially indicated, though the evidence thereto is by no means conclusive.

(2) WESTINGHOUSE.

The Westinghouse group contains the following companies:

The Security Investment Company;

Electric Properties Company (New York, 1906), Westinghouse, Church, Kerr & Co., subsidiary of Electric Properties Company.

Smith interests, represented by C. Elmer Smith and S. Fahs Smith, of S. Morgan Smith Company, important manufacturers of water

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turbines. While C. Elmer Smith is interested in at least two General Electric power companies (Carolina and Rockingham; see above), the Smith interests seem especially harmonious with the Westinghouse group, and are so classified.

The individual names most prominently identified are:

John F. Wallace, of New York, president Electric Properties Company.

George C. Smith, of Pittsburg and New York, vice-president of the Security Investment Company and vice-president and director of the Electric Properties Company.

C. Elmer Smith, of Smith interests.

(*a*) Those power companies which are admittedly Westinghouse are:

Atlanta Water and Electric Power Company, on the Chattahoochee River above Atlanta, Ga., with an installation of 17,000 horsepower. C. Elmer Smith is president, and George C. Smith and S. Fahs Smith directors.

Ontario Power Company of Niagara Falls, a Canadian corporation on the Canadian side, with an installation of 66,000 horsepower. Together with its distributing company in the United States, the Niagara, Lockport, and Ontario Power Company, it is known as a Westinghouse concern, H. H. Westinghouse being president of the latter, and stock being held therein by the Security Investment Company (Westinghouse).

(*b*) Those power companies whose connection with Westinghouse interests is inferred from substantial evidence are:

Albany Power and Manufacturing Company, near Albany, Ga., with 3,500 horsepower installed, on the Kinchatoonee, and owning beside a site on the Flint River, estimated at 10,000 horsepower, has for its vice-president C. Elmer Smith (Smith interests).

Electric Manufacturing and Power Company, on the Broad River, near Spartanburg, S. C., with 11,000 horsepower installed, has on its directorate E. H. Jennings, of Pittsburg, a director of the Electric Properties Company (Westinghouse).

Savannah River Power Company, on the Savannah River, near Anderson, S. C., has an installed development of 3,000 horsepower, and owns besides a site of 6,000 horsepower. This company has on its directorate C. Elmer Smith (Smith interests).

Gainesville Electric Railway Company, with 1,500 horsepower installed, on the Chestagee River, a tributary of the Chattahoochee, near Gainesville, Ga. Eighty-five per cent of its stock is owned by the North Georgia Electric Company (Smith interests).

North Georgia Electric Company; one development of 3,000 horsepower and at least seven other power sites on the upper waters of the Chattahoochee, and through the Etowah Power Company, personally identified with itself, it owns four other sites on the headwaters of the Coosa River. C. Elmer Smith is vice-president.

Chattanooga and Tennessee River Power Company, in process of construction at Hale Bar, on the Tennessee River, below Chattanooga, in cooperation with the War Department, by which the Government obtains slack-water navigation. The company in return receives ownership of the power of 58,000 horsepower to be installed. This company is being personally financed by A. N. Brady, of New York, a director of the Westinghouse Electric and Manufacturing Com-

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pany. Mr. Brady is also a director of the American Tobacco Company, whose interests control the Southern Power Company (see below).

Northern Colorado Power Company, with a steam development at Lafayette, Colo., and reported as having acquired a water power site of 20,000 horsepower on South Platte River, has John F. Wallace and George C. Smith of the Electric Properties Company (Westinghouse) on its directorate.

(*c*) Control partially indicated.

There are also a number of other water-power companies, with a total of about 102,000 horsepower (including installations and sizes), whose connection with the Westinghouse Company is at least partially indicated, though the evidence thereto is by no means conclusive.

(3) OTHER CONCENTRATIONS.

The General Electric and Westinghouse companies present the most important examples of water-power concentration, as above set forth. There are, however, a number of other companies and interests further showing the facts and tendencies of concentration.

The more important instances are as follows:

The Gould interests located in Virginia, with undeveloped powers and power sites on the James and Appomattox amounting to 20,000 horsepower, and owning besides other sites on the Appomattox and Rappahannock rivers.

Southern Power Company, the largest operating power company in the South, has 90,000 horsepower installed in three developments, 31,000 horsepower in process of construction, and at least seven other power sites in North Carolina and South Carolina, with a total potential capacity of 75,000 horsepower. This company supplies 110 cotton mills and other factories in at least 28 towns, including a population of about 200,000. Messrs. B. N. Duke, J. B. Duke, and Junius Parker, of the American Tobacco Company, are officers and directors.

Stone & Webster, of Boston. This concern controls or manages powers and power sites in Florida, Georgia, Minnesota, and Wisconsin, and in the Puget Sound region, with a total capacity of about 150,000 horsepower. Mr. Sydney Z. Mitchell, now of the Electric Bond and Share Company (General Electric), was formerly connected with Stone & Webster, and in 1908, according to Moody's Manual, 1908, was still a director in three of Stone & Webster's managed corporations, to wit, Puget Sound Electric Railway, Tacoma Railway and Power Company, and Puget Sound Power Company.

Charles H. Baker interests; having proposed developments in Alabama estimated at 130,000 horsepower.

Commonwealth Power Company, together with the Grand Rapids-Muskegon Power Company (both under same interests), controlling 13 developed water powers in Michigan, with a total installation of 43,000 horsepower. A harmonious connection apparently exists with the Eastern Michigan Power Company, which controls all the power sites on the Au Sable River, Michigan.

United Missouri River Power Company, a holding company controlling at least three subsidiaries, which, with a closely related company, have five developed powers and one in construction, making a total of 57,500 horsepower.

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Portland General Electric Company, with developments on the Clackamas and Willamette rivers amounting to 22,500 horsepower, near Portland, Oreg. A. C. Bedford, a director of the Standard Oil Company, is president, and F. D. Pratt, also of Standard Oil Company, is a director.

Pacific Gas and Electric Company. This is a very important holding company of the California Gas and Electric Corporation and the San Francisco Gas and Electric Company. These two latter companies in turn represent the consolidation or acquisition of the stock or property of over thirty power or power-distributing companies in California. They control 11 water-power developments, with a total installed plant of 118,000 horsepower.

Pacific Light and Power Company, with another company controlled by the same interests, known as the Huntington interests, represent eight developments in California, with a total of 30,000 horsepower. Henry E. Huntington is vice-president and Howard E. Huntington a director.

Edison Electric Company, with six developments in California and a total of 33,000 horsepower. This company is reported to have control of about 75 per cent of the available undeveloped water powers in southern California.

Hudson River Electric Power Company, a holding company for the Hudson River Water Power Company, Hudson River Power Transmission Company, Empire State Power Company, with developments at Spiers Falls and Mechanicsville on the upper Hudson, and Schoharie Creek near Amsterdam, N. Y., amounting to 45,000 horsepower installed, and sites owned in the Mohawk, Sacandaga, and upper Hudson valleys, amounting to 30,000 horsepower, or a total of 75,000 horsepower. C. Elmer Smith was director of the holding company to within a year.

Telluride Power Company, together with the Beaver River Power Company, controlled by the same interests, has 11 developments in Colorado, Utah, and Idaho, with a total present installation of 52,000 horsepower.

SUMMARY.

An estimate of the water power, developed and potential, now controlled by the General Electric interests, admitted or sufficiently proven, is about 252,000 horsepower; by the Westinghouse interests, similarly known, about 180,000 horsepower, and by other large power companies, 875,000 horsepower. This makes a total of 1,307,000 horsepower. Adding the horsepowers of the third class (*c*), those whose connection with these two great interests is at least probable, to wit, 520,000 horsepower, we have a small group of 13 selected companies or interests controlling a total of 1,879,000 horsepower developed and undeveloped.

Assuming that the water power at present in use by water-power plants in the United States is 5,356,000 horsepower, as estimated by the United States census and the Geological Survey from figures of installation, we see that approximately a quantity of horsepower equal to more than 35 per cent of that amount is now probably controlled by this small group of interests. Furthermore, this percentage by no means tells the whole truth. The foregoing powers naturally represent a large proportion of the best power sites. These sites are

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strategic points for large power and market control. Poorer sites will not geenerally be developed until these strategic sites are developed to their full capacity. And should these strategic sites be "coupled up" they become still more strategic. There are powerful economic reasons for such coupling. The great problem of water-power companies is not only that of the "uneven load," common to all power companies, but especially that of an uneven source of power, because of the fluctuating flow of the stream. A coupling up utilizes not only the different storages in the same drainage basin, but, of still greater import, the different drainage flows of different basins. Also, by coupling up, powers which have largely "day loads" can at night help out other powers which have largely "night loads," and vice versa. Coupling up is rapidly in progress in the United States. The Niagara Falls Power Company and the Canadian Niagara Power Company are coupled. The Southern Power Company, in North Carolina and South Carolina; the Commonwealth Power Company, in Michigan; the Pacific Gas and Electric Company, the Pacific Light and Power Company, and the Edison Electric Company, in California—each concern has its various developments coupled up into one unit.

The economic reasons urging water-power concentration are thus obvious. The facts set forth above show the very rapid and very recent concentration that has already occurred, practically all in the last five years. These economic reasons and business facts indicate clearly the further progress toward concentration that is likely to occur in the near future. It is obvious that the effect on the public of such present and future conditions is a matter for serious public consideration.

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CONTROL OF CATCHMENT AREAS.

By HORATIO N. PARKER,
Water Resources Branch, United States Geological Survey.

Catchment areas, annual consumption, and total money investment of the water works of 42 cities which derive their water supplies from impounded surface waters and which have populations of over 30,000.

City.	Catchment area.	Reservoir capacity.	Annual consumption.	Total investment.		
				Cost of construction.	Bonded indebtedness.	Maintenance.
	Sq. miles.	*Gallons.*	*Gallons.*			
Altoona, Pa.	9.00	[a] 425,000,000	547,500,000	$910,148	$479,000	$45 090
Baltimore, Md.	347.00	2,310,000,000	22,995,000,000	12,000,000	850,000	400,000
Boston, Mass.	[b] 212.38	82,966,530,000	40,250,000,000	40,459,778	40,500,000	318,052
Bridgeport, Conn.	40.80	10,000,000	7,300,000,000	.....	.....	.....
Brockton, Mass.	7.70	5,700,000,000	714,340,000	1,713,300	1,485,000	38,000
Butte, Mont.	.....	290,000,000	2,190,000,000	.....	.....	.....
Cambridge, Mass.	6.80	2,270,000,000	3,386,180,000	6,467,153	3,787,600	75,702
Charleston, S. C.	49.00	3,127,820,000	1,204,500,000	2,456,682	1,250,000	52,245
Denver, Colo.	3,910.00	110,000,000,000	15,881,000,000	.....	.....	.....
Elmira, N. Y.	.....	117,500,000	1,546,900,000	895,000	.....	115,000
Fall River, Mass.	27.54	.....	1,640,000,000	2,076,450	1,550,000	124,972
Fitchburg, Mass.	7.40	2,000,000	1,095,000,000	1,400,000	446,000	37,300
Hartford, Conn.	13.00	2,035,000,000	2,190,000,000	3,567,191	675,000	150,000
Haverhill, Mass.	20.10	128,000,000	1,839,000,000	1,463,047	610,833	25,137
Holyoke, Mass.	18.05	1,600,000,000	2,127,840,000	1,295,308	350,000	61,712
Jersey City, N. J.	.....	129,200,000	12,045,000,000	5,200,000	600,000	445,000
Johnstown, Pa.	5.50	283,000,000	.....	1,500,000	.....	.....
Los Angeles, Cal.	502.50	898,000,000	11,680,000,000	[j] 3,983,693	[k] 3,480,250	201,107
Lynn, Mass.	.....	.....	1,873,450,000	2,900,891	1,778,500	117,389
Newark, N. J.	.....	9,000,000,000	93,482,500,000	8,959,790	7,993,500	250,000
New Bedford, Mass.	[c] 12.80	[d] 5,550,000,000	2,524,661,000	3,332,800	1,638,000	109,443
New Haven, Conn.	56.40	2,837,000,000	8,395,000,000	.....	.....	.....
New York, N. Y. (boroughs of Manhattan and Bronx)	[e] 382.00	[f] 108,638,000,000	[f] 119,720,000,000	[g] 86,359,562	.....	1,000,000
Norfolk, Va.	.....	.....	2,482,000,000	1,250,000	.....	.....
Oakland, Cal.	.....	6,300,000,000	.....	4,520,000	.....	100,000
Pawtucket, R. I.	27.80	1,475,600,000	2,633,000,000	1,946,848	1,285,000	53,153
Portland, Me.	.....	30,000,000	2,190,000,000	2,677,970	.....	.....
Portland, Oreg.	.....	6,000,000	6,935,000,000	5,204,650	2,900,000	78,516
Reading, Pa.	218.60	186,022,000	3,768,260,000	33,213,725	400,000	50,316
Rochester, N. Y.	[h] 66.20	229,500,000	5,621,000,000	9,028,000	5,610,000	115,000
St. Paul, Minn.	.....	18,000,000	3,732,000,000	4,517,329	2,367,000	60,337
Salem, Mass.	.....	20,000,000	1,090,426,000	1,947,200	143,000	31,306
Salt Lake City, Utah.	.....	9,012,000	5,110,000,000	4,810,000	1,575,000	55,000
San Francisco, Cal. (prior to fire)	.....	29,000,000,000	12,344,665,000	.....	.....	554,000
Scranton, Pa.	.....	2,000,000,000	9,125,000,000	.....	.....	.....
Springfield, Mass.	[i] 18.00	1,500,000,000	4,000,000,000	2,509,525	555,000	54,700
Syracuse, N. Y.	70.25	121,000,000	4,380,000,000	5,000,000	4,075,000	100,000
Taunton, Mass.	52.00	10,300,000,000	818,774,000	1,367,801	853,500	33,988
Waterbury, Conn.	19.50	920,000,000	2,728,831,000	1,819,640	865,000	24,000
Wilkesbarre, Pa.	.....	4,000,000	.....	.....	.....	.....
Worcester, Mass.	.....	2,550,000,000	2,954,617,000	4,406,202	3,830,000	60,000

[a] Exclusive of a reservoir of 300,000,000 gallons capacity.
[b] Metropolitan Water Works.
[c] Exclusive of a storage reservoir in Acushnet, which has a catchment area of 5.25 square miles.
[d] An additional storage reservoir of 1,600,000,000 gallons capacity is under construction.
[e] On Croton, Bronx, and Byram rivers.
[f] On Croton River, including the new Croton reservoir to be finished in 1911, and on Bronx and Byram rivers.
[g] 1832 to 1896, inclusive.
[h] Exclusive of Hemlock Lake.
[i] Little River supply, now 40 per cent completed, is to replace present supply; will have a catchment area of 48 square miles and storage capacity of 2,600,000,000 gallons.
[j] Amount spent since the works were taken over by the city in February, 1902.
[k] Original, 4,017,500.

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ORIGINAL FORESTS.

By R. S. KELLOGG,
United States Forest Service.

The original forests of the United States exceeded in the quantity and variety of their timber the forests of any other region of similar size on the globe. Five great forest types were distinguished—the northern, southern, central, Rocky Mountain, and Pacific coast. Their boundaries are roughly sketched in the accompanying diagram.

The northern forests extended from Maine through New England, across New York and considerable of Pennsylvania, through the main portions of Michigan and Wisconsin to Minnesota, with an extension along the high Appalachian ridges as far southwestward as northeastern Alabama and northern Georgia. Roughly, it covered some 150,000,000 acres. In this forest the cone-bearing trees predominated. It was the home of the white pine. Associated with it were red pine, spruce, hemlock, cedar, balsam fir, the birches, black cherry, sugar maple, and several other hardwoods of minor importance. The total stand of timber of all kinds in the northern forest originally was not less than 1,000,000,000,000 board feet.

The northern extremity of the southern forest was in southern New Jersey, widening out southward and westward to cover much of Virginia, nearly all of North Carolina and South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, with a portion of eastern Texas and southern Arkansas, and a small extension into southern Missouri. This, too, was a coniferous forest. The yellow pines predominated heavily. Interspersed with the pines in localities suitable for their growth were cypress, oaks, gums, magnolia, yellow poplar, and a variety of other hardwoods. The total original area of this forest was perhaps 220,000,000 acres, and it contained at least 1,000,000,000,000 feet of merchantable timber.

In rough outline, the central forest stretched from the Atlantic coast to the prairies, with limitations on the other two sides by the northern and southern forests. There were no sharp demarcations between it and the other types, and it was extremely irregular in shape. It was the only forest region of the United States in which the hardwoods predominated, and they occurred in extreme abundance. Walnut, oak, elm, hickory, cottonwood, maple, basswood, chestnut, sycamore, red gum, ash, and many other trees here reached their maximum development. It can be conservatively estimated that the original area of the central hardwood forest was not less than 280,000,000 acres, and that the amount of merchantable timber standing upon it before clearing began was at least 1,400,000,000,000 board feet.

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The Rocky Mountain forest, as its name indicates, was typical of the Rocky Mountain region from Idaho and Montana through Wyoming, Utah, and Colorado to Arizona and New Mexico. It was separated by the prairie and the plains region from the eastern forests and by desert areas from the Pacific forest. This forest grew chiefly on the higher plateaus and mountain slopes and was almost entirely coniferous. Western yellow pine occurred throughout, while lodgepole pine, larch, spruce, Douglas fir, giant arborvitæ, and other softwoods were abundant in many localities. The broken character of this forest makes the timber and area extremely difficult to estimate. It is probable, however, that the original extent was not less than 110,000,000 acres, and that it contained 400,000,000,000 board feet of merchantable saw timber.

The Pacific type of forest characterized California, Oregon, and Washington, reaching its maximum development along the Sierras and west of the Cascade Range. So far as saw timber was concerned it was almost exclusively a coniferous forest, and consisted chiefly of Douglas fir, western yellow pine, redwood, giant aborvitæ, sugar pine, and various other firs and spruces. The original area of this forest was at least 90,000,000 acres, and the amount of merchantable timber which it contained was not less than 1,400,000,000,000 board feet.

Without exaggeration, then, we may say that the original forests of the United States covered 850,000,000 acres and contained 4,800,000,000,000 board feet of merchantable saw timber according to present standards of utilization. In addition there were probably 150,000,000 acres of scrubby forest and brush land, chiefly in the West, which has been and still is a source of much post and fuel material.

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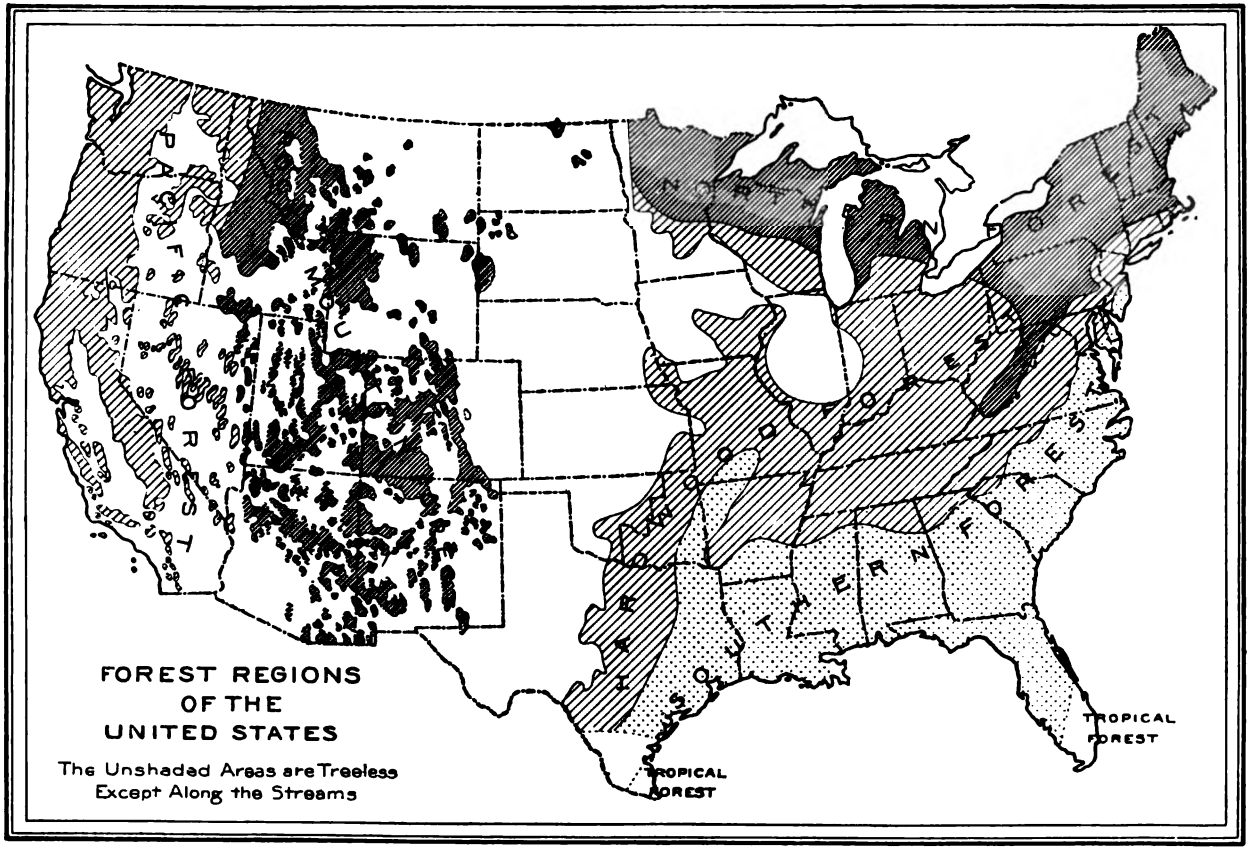

FIG. 1.

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STANDING TIMBER IN WOOD LOTS.

By WESLEY BRADFIELD.
United States Forest Service.

The amount of woodland owned by farmers in the United States, together with the amount of stumpage which they control, bears a very important relation to the total amount of timberland and the total resources of the country. Although the estimates given in this report are subject to revision, they are as nearly correct as may be obtained at the present time.

It is estimated that the farmers own 38 per cent of the total area of forest land and 12.4 per cent of the total amount of merchantable timber. On the average, not more than 30 per cent of these resources reaches the general timber markets of the country; this amount affects only local sections, as the greater percentage of the timber cut from farmers' wood lots is consumed in the vicinity of cutting. This percentage is practically all that can be relied upon at the present time from this source of ownership to aid in meeting the general market demands. For, while a certain percentage of young timber is gradually reaching a merchantable size, the acreage in farmers' holdings is gradually decreasing, mainly through the clearing of woodland for agriculture, and the amount of timber available for the future is more rapidly decreasing, because the farmer's wood lot is by no means reserved entirely for the production of a future supply for the owner or for the local markets. A far more important place, however, is held by the wood lot in that it provides a great amount of timber of all sorts needed on the farm for rough building, general repairs, fences, and fuel. This timber is not always used to the best advantage, and it is very evident that if this source of supply were more carefully managed, the influence which the farmers' holdings have on the general market would be much greater than at the present time.

It is estimated that in the whole United States the farmers own over 204,000,000 acres of woodland, 46 per cent of which contains merchantable timber, 43 per cent cord-wood timber, and 11 per cent is in brush land. The estimated stand on these holdings is 311,000,000,000 feet of timber and 1,500,000,000 cords of wood.[a] Its dis-

[a] In addition to approximately 1,000,000 cords of wood on the second type of woodland, there are also half a million cords of wood on the merchantable timbered area not included in the tabular estimates.

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tribution throughout the eastern and western halves of the United States is shown by the following table:

Percentage of total area of section owned by farmers.

	In the East.	In the West.
Per cent of total woodland	52	7
Per cent of total acreage	94	6
Per cent of wood-lot area containing merchantable timber	43	83
Per cent of wood-lot area containing cord wood	45	14
Per cent of wood-lot area in brush land	12	3
Per cent of stand of timber in wood lots	74	26
Per cent of cord wood in wood lots	99	1

This table shows that in the eastern half of the United States the percentage of the total amount of woodland owned by the farmers is about one-half of the total timber acreage in that section of the country. The relative importance of the farmers' holdings in the western half is very small, as they own only 7 per cent of the total timber acreage, and practically none of their timber has any effect on general market conditions. Provided that the quality of the timber remains the same, the money value of the farmers' wood-lot holdings represents even the smaller proportion in its relation to the total value of the timber stumpage, as these holdings are isolated and can be exploited only at a cost which is greater in proportion to the expense of marketing the timber held by all other sources.

The relation of the farmers' wood lot to the total forested area throughout the United States is given in more detail in the following groups of States:

In the New England States, together with New York and New Jersey, 47 per cent of the forested area is held by farmers. Of this amount 29 per cent is merchantable timber land, 54 per cent is cord-wood-timber land, and 17 per cent is brush land. The stumpage owned by farmers is approximately 15,798,000,000 feet and over 96,000,000 cords of wood. The general quality of the merchantable timber is of medium grade. The predominating species are the oaks and chestnut; spruce and white pine; maple, birch, and hickory. The cord-wood land in this and in all of the following sections represents a potential future timber production of very great importance, as the forests on this cord-wood land, so called, is rapidly growing into the merchantable timber class.

In the States of Delaware, Maryland, and Virginia, 81 per cent of the woodland is owned by farmers, of which 42 per cent contains merchantable timber, 50 per cent is cord-wood timber land, and 8 per cent is brush land. The stand of timber in these States is approximately 15,634,000,000 feet and 49,000,000 cords of wood. The quality of the merchantable timber is poor. The predominating species are the oaks, chestnut, maple, beech, hickory, and basswood, with scattered stands of loblolly pine, pitch pine, and scrub pine.

In the South Atlantic and Gulf States 50 per cent of the woodland is owned by farmers, of which 48 per cent contains merchantable timber, 40 per cent is cord-wood land, and 12 per cent brush land. The stand of timber in wood lots is approximately 110,426,000,000 feet and 332,000,000 cords of wood. The quality of the mer-

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chantable timber is good. The predominating species are longleaf, shortleaf, and loblolly pine, and cypress along the coastal plain; oaks, beech, maple, and other hard woods throughout the mountain section.

In the States of Pennsylvania, West Virginia, Kentucky, and Tennessee 62 per cent of the woodland is owned by farmers, of which 38 per cent contains merchantable timber, 50 per cent is cord-wood land, and 12 per cent is brush land. The stand of timber is approximately 33,332,000,000 feet and 111,000,000 cords of wood. The quality of the merchantable timber is poor. The predominating species are the black oaks, beech, maple, white oak, chestnut oak, chestnut, and hickory in the mountain regions, and black oak, beech, white oak, hickory, gums, and maple in the better agricultural regions.

In the Lake region the farmers own 40 per cent of the timber-land area, of which 40 per cent contains merchantable timber, 41 per cent is cord-wood land, and 19 per cent is brush land. The stand of merchantable timber is approximately 24,003,000,000 feet and 119,000,000 cords of wood. The quality of the merchantable timber is good. The predominating species are the oaks, elm, basswood, hickory, maple, beech, birch, white pine, Norway pine, and jack pine.

In Arkansas and Missouri 49 per cent of the timber-land area is owned by farmers; of this acreage 51 per cent contains merchantable timber, 43 per cent is cord-wood land, and 6 per cent is brush land. The stand of timber is approximately 20,748,000,000 feet and 70,000,000 cords of wood. The quality of merchantable timber is poor. The predominating species are black, post, pine, white, and chinquapin oaks, sycamore, gums, and elms.

In the prairie States, which contain only a small percentage of timber land in comparison with their total area, the farmers own 70 per cent of the woodland. Of this amount 37 per cent contains merchantable timber, 48 per cent is cord-wood land, and 15 per cent is brush land. The stand of timber is approximately 11,799,000,000 feet and 51,000,000 cords of wood. The quality of the merchantable timber is poor. The predominating species are the oaks, maple, elm, sycamore, cottonwood, and birch. All of the above States are included in the eastern half of the United States.

In the West the farmers own only 7 per cent of the total acreage of forest land, of which 83 per cent is merchantable timber land, 14 per cent cord-wood land, and 3 per cent brush land. The stand of timber on farmers' holdings is approximately 79,480,000,000 feet and 9,000,000 cords of wood. To show more definitely the relation between the farmers' holdings in the East and the West, the eastern half of the United States contains 94 per cent of the total acreage owned by farmers, 89 per cent of the wood-lot area which contains merchantable timber, 98 per cent of the wood-lot area containing cord wood only, 99 per cent of the brush-land area, 74 per cent of the total amount of stumpage owned by farmers, and 99 per cent of the total amount of cord wood on farmers' holdings.

Although the amount of standing timber in wood lots is comparatively small, it is very evident that the supply of timber which may be derived from farmers' wood lots can be greatly increased over the present percentage of merchantable timber which the farmers place on the market. Over one-fourth of the wood-lot area in the

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eastern half is in or adjacent to coal and gas regions, where the demand for firewood for local consumption is very small. For this reason it is estimated that over 50 per cent of the wood-lot area need not be depended upon to furnish the local supply of fuel. The demands of the farmer on the average wood lot for building material, fence posts, and other incidental timber uses on the farm are not very great in proportion to the total amount which the farmers' wood lots contain. At the present time a rather indiscriminate use is made of the timber in farmers' wood lots, and but little attention is paid to other than the immediate demand of the owner and to what material can be most easily secured to meet this demand. It is safe to say that, of the timber acreage alone, from 50 to 60 per cent could be safely counted upon to meet local demands other than those of the owners themselves.

The present rate of production of timber in farmers' wood lots does not exceed 30 cubic feet of wood per acre per year throughout the eastern half of the United States. In a great many sections the actual production of cubic feet per acre per year is exceedingly small, or perhaps nothing at all. This is because the wood lots in many cases contain a very high percentage of mature timber which has reached its maximum productive capacity, or because the farmers' wood lots are also used for pasturing and other purposes which greatly decrease the normal amount of annual production which would otherwise be obtained.

As a rule, farmers' wood lots may be said to occupy excellent sites for timber growing, as the character and fertility of the soil and the moisture which the soil contains are practically the same as that of the agricultural land on the remaining parts of the farms, and in many cases differ only from the remaining parts of the farms in being land which is too rough to cultivate. The unit of production on the wood lots in the eastern half of the United States should average from 60 to 70 cubic feet per acre per year. This would practically double the amount of timber which might be placed on the market over that which is now sold locally, while with greater care in the local use of the timber needed on the farm the amount of timber which might be placed on local markets would even be much greater.

Thus it will be seen that the relation which farmers' holdings bear to the total timber acreage in the country and the proportionate amount of timber with which they supply the local markets is very important, especially throughout the eastern half of the United States. Should their proportionate timber acreage slightly decrease every year, an increased production of over 100 per cent may be obtained on their future holdings. Wood-lot timber is cut more conservatively than the timber of other holdings in the East and may become a more important factor in the question of furnishing local timber supplies than it is at the present time. This demonstrates the very great need of more conservative and more intensive management of the timber land owned by the farmers in the United States.

This can only be brought about by the farmers themselves. They should be more thoroughly acquainted with the way in which to better care for and grow their timber supplies as well as the marketing of the timber which they now own.

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Wood lots.

State	Total land area.	Area of woodland.	Per cent of woodland owned by farmers.	Area of wood lots.	Per cent of woodlot area containing merchantable timber.	Area of wood lots containing merchantable timber.	Per cent of woodlot area containing cordwood only.	Area of wood lots containing cordwood only.	Per cent of brushland area in wood lots.	Area of brush land in wood lots.	Total stand of merchantable timber in wood lots.	Total stand of cordwood in wood lots.
	Acres.	*Acres.*		*Acres.*		*Acres.*		*Acres.*		*Acres.*	*Million feet b. m.*	*M cords.*
Maine	19,132,800	14,900,000	25	3,725,000	37	1,378,000	62	2,310,000	1	37,000	1,920	39,820
New Hampshire	5,779,840	3,500,000	51	1,785,000	36	643,000	41	732,000	23	410,000	778	10,220
Vermont	5,839,360	2,500,000	55	1,375,000	18	247,000	70	963,000	12	165,000	1,368	12,760
Massachusetts	5,144,960	2,000,000	75	1,500,000	35	525,000	41	615,000	24	360,000	1,050	9,235
Rhode Island	682,880	250,000	95	238,000	4	10,000	71	169,000	25	59,000	70	338
Connecticut	3,084,800	1,600,000	88	1,408,000	37	521,000	40	563,000	23	324,000	1,563	16,900
New York	30,498,560	12,000,000	59	7,080,000	30	2,124,000	55	3,894,000	15	1,062,000	8,590	2,561
New Jersey	4,808,960	2,000,000	62	1,240,000	37	459,000	49	608,000	14	173,000	459	4,825
Total	74,972,160	38,750,000	47	18,351,000	32	5,907,000	54	9,854,000	14	2,590,000	15,798	96,659
Delaware	1,257,600	350,000	66	231,000	42	97,000	53	122,000	5	12,000	364	547
Maryland	6,362,240	2,200,000	76	1,672,000	60	1,003,000	35	585,000	5	84,000	2,110	4,770
Virginia	25,767,680	14,000,000	82	11,470,000	39	4,473,000	52	5,965,000	9	1,032,000	13,160	43,700
Total	33,387,520	16,550,000	81	13,373,000	42	5,573,000	50	6,672,000	8	1,128,000	15,634	49,017
North Carolina	31,193,600	19,600,000	53	10,390,000	33	3,400,000	51	5,300,000	16	1,660,000	12,850	66,300
South Carolina	19,516,800	12,000,000	60	7,200,000	34	2,448,000	57	4,104,000	9	648,000	7,481	57,900
Georgia	37,584,000	22,300,000	70	15,820,000	43	6,810,000	48	7,590,000	9	1,420,000	22,000	21,625
Alabama	32,818,560	20,000,000	44	8,800,000	41	3,608,000	42	3,696,000	17	1,496,000	8,760	34,050
Florida	35,111,040	20,000,000	17	3,400,000	50	1,700,000	29	986,000	21	714,000	3,165	17,680
Mississippi	29,671,680	17,500,000	52	9,100,000	52	4,732,000	40	3,640,000	8	728,000	15,920	23,930
Louisiana	29,061,760	16,500,000	38	6,270,000	77	4,828,000	20	1,254,000	3	188,000	20,300	18,340
Texas	167,934,720	30,000,000	60	18,000,000	56	10,080,000	31	5,580,000	13	2,340,000	19,950	91,640
Total	382,892,160	157,900,000	50	78,980,000	48	37,636,000	40	32,150,000	12	9,194,000	110,426	331,965
Pennsylvania	28,692,480	9,200,000	53	4,875,000	29	1,414,000	57	2,779,000	14	682,000	2,820	38,570
West Virginia	15,374,080	9,100,000	43	3,910,000	37	1,447,000	44	1,720,000	19	743,000	7,092	21,080
Kentucky	25,715,840	10,000,000	74	7,400,000	38	2,812,000	54	3,996,000	8	592,000	8,260	21,100
Tennessee	26,679,680	15,000,000	72	10,800,000	44	4,752,000	45	4,860,000	11	1,188,000	15,160	30,500
Total	96,462,080	43,300,000	62	26,985,000	39	10,425,000	50	13,355,000	12	3,205,000	33,332	111,250

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Wood lots—Continued.

State.	Total land area.	Area of woodland.	Per cent of woodland owned by farmers.	Area of wood lots.	Per cent of wood-lot area containing merchantable timber.	Area of wood lots containing merchantable timber.	Per cent of wood-lot area containing cordwood only.	Area of wood lots containing cordwood only.	Per cent of brush-land area in wood lots.	Area of brush land in wood lots.	Total stand of merchantable timber in wood lots.	Total stand of cordwood in wood lots.
	Acres.	*Acres.*		*Acres.*		*Acres.*		*Acres.*		*Acres.*	*Million feet b. m.*	*M cords.*
Ohio	26,073,600	4,800,000	97	4,655,000	50	2,328,000	37	1,722,000	13	605,000	3,808	27,560
Indiana	22,966,400	4,000,000	91	3,640,000	48	1,747,000	38	1,383,000	14	510,000	4,511	15,670
Michigan	36,787,200	15,500,000	30	4,650,000	37	1,720,000	45	2,093,000	18	837,000	6,100	35,900
Wisconsin	35,363,840	16,000,000	33	5,280,000	34	1,795,000	37	1,954,000	29	1,531,000	6,120	16,390
Minnesota	51,749,120	15,500,000	29	4,495,000	34	1,528,000	47	2,112,000	19	855,000	3,464	23,270
Total	172,940,160	55,800,000	40	22,720,000	40	9,118,000	41	9,264,000	19	4,338,000	24,003	118,790
Arkansas	33,616,000	24,200,000	44	10,650,000	61	6,500,000	35	3,730,000	4	420,000	13,220	32,400
Missouri	43,985,280	18,300,000	56	10,250,000	40	4,100,000	52	5,330,000	8	820,000	7,528	37,100
Total	77,601,280	42,500,000	49	20,900,000	51	10,600,000	43	9,060,000	6	1,240,000	20,748	69,500
Illinois	35,841,280	2,500,000	90	2,250,000	41	923,000	42	945,000	17	382,000	6,970	11,770
Iowa	35,575,040	2,500,000	94	2,350,000	31	729,000	50	1,175,000	19	446,000	530	2,162
Oklahoma	44,424,960	8,000,000	54	4,320,000	58	2,506,000	31	1,339,000	11	475,000	3,555	21,600
Kansas	52,335,360	1,000,000	95	950,000	5	47,000	80	760,000	15	143,000	704	6,080
Nebraska	49,157,120	800,000	97	776,000	3	23,000	85	660,000	12	93,000	22	4,620
North Dakota	44,917,120	600,000	100	600,000	2	12,000	73	438,000	25	150,000	12	3,508
South Dakota	49,195,520	1,200,000	25	300 000	2	6,000	73	219,000	25	75,000	6	1,751
Total	311,446,400	16,600,000	70	11,546,000	37	4,246,000	48	5,536,000	15	1,764,000	11,799	51,491
Total for eastern United States		371,400,000	52	192,855,000	43	83,505,000	45	85,891,000	12	23,490,000	231,740	828,672
Montana	93,296,640	18,000,000	2	360,000	95	342,000	3	11,000	2	7,000	1,676	34
Wyoming	62,460,160	10,000,000	1	100,000	98	98,000	1	1,000	1	1,000	1,243	6
Colorado	66,341,120	12,000,000	4	480,000	53	255,000	43	206,000	4	19,000	822	1,012
Idaho	53,618,560	20,000,000	2	400,000	97	388,000	2	8,000	1	4,000	5,560	44
Utah	52,597,760	6,000,000	5	300,000	69	207,000	25	75,000	6	18,000	913	395
Arizona	72,857,600	14,000,000	1	140,000	95	133,000	4	6,000	1	1,000	168	30
New Mexico	78,401,920	12,000,000	5	600,000	96	576,000	3	18,000	1	6,000	230	91
Nevada	70,285,440	5,000,000	1	50,000	96	48,000	3	1,500	1	500	48	8
Total	549,859,200	97,000,000	3	2,430,000	85	2,047,000	13	326,500	2	56,500	10,660	1,620

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Washington	42,775,040	25,000,000	12	3,000,000	73	2,190,000	24	720,000	3	90,000	16,060	3,554
Oregon	61,188,480	27,000,000	10	2,700,000	87	2,349,000	9	243,000	4	108,000	41,280	1,142
California	99,898,880	24,000,000	16	3,840,000	86	3,302,000	12	461,000	2	77,000	11,480	2,187
Total	203,862,400	76,000,000	13	9,540,000	82	7,841,000	15	1,424,000	3	275,000	68,820	6,883
Total for western United States		173,000,000	7	11,970,000	83	9,888,000	14	1,750,500	3	331,000	79,480	8,508
Grand total	1,903,423,360	544,400,000	38	204,825,000	46	93,393,000	43	87,641,500	11	23,790,500	311,220	837,175

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STAND OF TIMBER.

By HERBERT KNOX SMITH,
Commissioner of Corporations.

The field work of the Bureau of Corporations on the quantity of standing timber covered those parts of Virginia, North Carolina, South Carolina, and Georgia, south and east of the mountains, and the timbered parts of the following States: Florida, Alabama, Mississippi, Louisiana, Texas, Arkansas, Missouri, Michigan, Wisconsin, Minnesota, Montana, Idaho, Washington, Oregon, and California.

The estimate of the total amount of privately owned merchantable standing timber on this entire area, obtained by the methods described below, on the basis of product of lumber under present conditions, is 1,570,000,000,000 board feet. The Forest Service has estimated the standing timber on the forest reserves at 390,000,000,000 board feet; that on the unappropriated public lands, national parks, and Indian reservations, 59,000,000,000 and that on the state lands, 35,000,000,000. These figures, together with that obtained by the Bureau of Corporations, give a total of about 2,050,000,000,000 board feet. No detailed investigation has been made for the privately owned timber outside the area covered by the Bureau of Corporations, but the Forest Service has made a tentative estimate of 450,000,000,000 feet for it, making the total standing timber in the United States about 2,500,000,000,000 board feet.

A systematic inquiry into the amount of standing timber in the United States might be made by either of two methods; first, to examine the entire timber area of the country and thus obtain the information first hand. This would require a very long time and great expenditure. Even if cost were disregarded it would be practically impossible to secure a sufficient number of experts to finish the task within a reasonable time.

The second method is that of bringing together the best information on the subject now in the records of timber owners or within the personal knowledge of men engaged in the industry. Nearly all owners of important tracts have fairly good knowledge of the quantity of their timber, and they, together with others engaged in the timber and lumber business, are acquainted with the other timber in their several localities. From such sources quite satisfactory estimates on the total timber in the entire county, or in certain parts of it, such as townships, or on the total timber exclusive of specified large holdings, can be obtained. Thus the facts regarding large holdings can be secured, and an estimate on all timber in the county outside such holdings separately reported can be had by interviewing the men best informed on the county as a whole or on subdivisions of it. A comprehensive plan by which all of this information is brought together

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and compared, and the most accurate data for the various localities tabulated gives the best information regarding the timber supply which can be obtained under present conditions at reasonable cost.

The general plan adopted by the Bureau of Corporations was to obtain first a report from each owner of 50,000,000 board feet or more. This report included, among other items, the acreage and an estimate of the amount of timber in as great detail as could be had, and, wherever obtainable, the exact location of the land. When this information had been obtained it was so arranged as to show for each county the names of owners, locations of lands, and estimates, and from this the work was carried forward by securing general estimates on the total of all other holdings in the county. The constant effort was to secure the information in as much detail as possible, so that each man's judgment could be taken on the area with which he was most familiar. Thus, wherever practicable, these general estimates were made for the timber in the county exclusive of the large holdings previously obtained, and were also taken for subdivisions of the county, such as survey townships or political subdivisions. In case it was not possible to secure an estimate on all small holdings in such detail, the estimate was obtained on the total timber in the county, but in no case did the estimate cover a larger area than a county, although some individuals furnished separate estimates for a number of counties. The judgment of as many well-informed men as could be found was obtained for each county. A final estimate for the county was then reached by a consideration of all the evidence.

The chief difficulty in arriving at the amount of timber owned by those having 50,000,000 board feet and over is that all estimates are largely a matter of judgment, and their accuracy depends on the care used and the skill of the man making the estimate. Good cruisers often differ very materially on the same tract. Again, nearly all estimates are too low because most obtainable estimates were made for the use of buyers whose first care was for a safe judgment on the value of the property. Such estimates run all the lower because in many instances the buyers have needed only rough and partial estimates to assure them that they were getting at least enough timber to make them safe at the price paid, with the probability that there was considerably more timber on the tract.

Another difficulty is due to changes in the standards of merchantable timber as the price of lumber advances. Vast quantities of timber now counted as merchantable would not have been so counted fifteen years ago, and in some parts of the country an estimate made in 1900 must be greatly increased to represent the timber which is now merchantable. With higher prices more logs are brought to the mill from the same tract, and the manufacturer of lumber will make more board feet out of the same log because he is able to sell some boards not previously marketable. Again, some species of timber formerly regarded as worthless are now valuable. Therefore, it has been necessary to bring estimates made a number of years ago up to date. The date of the estimate and the conditions surrounding it were always secured, and the owner was asked what increase, in his judgment, should be made for such correction.

In addition to the statements furnished by the owner, other men having knowledge of the land were interviewed, and in many in-

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stances valuable information was obtained from those not directly interested in the property.

The general estimates on all small holdings in a county or on the total timber in a county are subject to varying percentages of error because of the imperfect knowledge of the informants. And while it is believed that such estimates are oftener too small than too great, they are not always so, and, therefore, to some extent at least, the error in one county is offset by an opposite error in another county.

Estimates on standing timber are not usually meant to give the most probable approximation to the quantity of lumber which would be produced at the mill, but instead a conservative approximation to the scale of the logs if cut, on which there would be an overrun at the mill. This point has been studied on the basis of answers to specific questions and also of general interviews with the best informed men; and for the principal subdivisions of the timber area percentages have been determined by which the totals of the estimates have been increased to cover both the error in estimates, as such, and the overrun from good estimates to mill output. Consequently the final figures are the best judgment obtainable from the investigation on the amount of lumber which would be produced from the merchantable standing timber if sawed under the conditions now existing in the lumber industry. Without question, as the price of lumber advances, a very considerable addition will be made to the supply of timber through the lowering of the standards of merchantable timber and the better use of such logs as are now sawed, but there is now no basis upon which this additional amount can be approximated.

The field work was a long and difficult task, and the office work necessary to judge carefully all reports on the vast area covered to determine the most accurate figures in cases of conflicting statements, and finally to compile the records thus established, has been much greater than would be judged offhand. There is inevitable error in statistical data on standing timber, and the best that can be done is to gather the information in as much detail as possible and from as many people as have knowledge of definite areas, and through an impartial study of all this material to arrive at the best possible approximation to the truth. It is believed that the errors in the results of this investigation are not large enough to affect materially their value for the purposes which they serve.

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STANDING TIMBER OWNED BY THE STATES.

By J. GIRVIN PETERS,
United States Forest Service.

The information regarding the stand of timber owned by individual States was obtained from state foresters and other state officials, and in a few cases from Forest Service officials. In many States the knowledge of the amount of timber owned is extremely meager, and the information furnished by a large majority was simply an estimate.

The total estimated amount of standing timber owned by the different States is 35,474,050,000 board feet, and the total area of State land forested is 9,460,622 acres.

The largest amount of timber owned by any State is that reported for New York, which is 8,600,000,000 board feet. Of the total amount reported by all the States, less than 10 per cent is hardwood. The bulk of the timber owned by the States located in the northern forest is spruce, white and Norway pine, hemlock, and cedar; in the southern forest, yellow pine; in the Rocky Mountain forest, western yellow pine, and in the Pacific coast forest, Douglas fir and redwood. The quality of the bulk of this timber is good, but not the best.

The following table shows the estimated amount of timber and forest land owned by the different States and Territories:

Estimated amount of standing timber and area of forest land owned by the different States and Territories.

State or Territory.	Amount.	Area forested.
	M feet B. M.	*Acres.*
Arizona	735,000	200,000
Arkansas	50,000	25,400
California	5,400,000	915,700
Colorado	680,000	572,800
Florida	625,000	250,000
Idaho	3,800,000	144,200
Maryland	250	1,957
Massachusetts	2,400	12,000
Michigan	480,000	120,000
Minnesota	2,519,900	2,695,187
Mississippi	170,000	180,800
Montana	1,158,900	1,000,000
Nevada	4,000	4,000
New Jersey	4,600	9,900
New Mexico	620,000	277,800
New York	8,600,000	1,599,638
North Carolina	225,000	125,000
Oklahoma	14,000	14,000
Oregon	5,000,000	502,840
South Dakota	125,000	59,400
Washington	5,000,000	500,000
Wyoming	260,000	250,000
Total	35,474,050	9,460,622

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STANDING TIMBER IN POSSESSION OF THE FEDERAL GOVERNMENT.

By G. M. HOMANS,
United States Forest Service.

The estimated amount of merchantable timber in the possession of the Federal Government, exclusive of Alaska, in its National Forests, Indian reservations, national parks, military reservations, and on unreserved public lands, is nearly 449,000,000,000 feet, b. m., and an unestimated amount of cord-wood, poles, posts, and mining timbers. Of this amount, over 86.7 per cent is within the national forests, 7.6 per cent within the Indian reservations, and over 3 per cent on the unreserved public lands. This material resource has an average value of $2.50 per thousand feet and represents a capital of $1,122,150,000.

The actual forested area now containing merchantable saw timber is approximately 92,629,500 acres, of which 81 per cent is national forests, 11 per cent Indian reservations, and 5 per cent unreserved public lands (Table 2).

In the Pacific coast region the stand per acre is much the heaviest and decidedly more variable. On the west slope of the Cascade Range selected acres of Douglas fir will often exceed 100,000 feet b. m., while on the east slope, in the yellow pine country, areas not exceeding 4,000 feet b. m. are very common. The average stand per acre is more uniform in the Rocky Mountain and eastern region since the forested area is comprised largely of pure stands and of species more uniform in volume.

The principal merchantable species in the Pacific coast region are, in the order of their predominance, Douglas fir, western yellow pine, white fir, hemlock, sugar pine, tamarack, redwood, and lodgepole pine. In the Rocky Mountain region the species having the greater commercial value are, in the order of their occurrence, lodgepole pine, yellow pine, Engelmann spruce, white fir, Douglas fir, western white pine, and cedar. The remaining merchantable area, with the exception of Arkansas and Minnesota, lies east of the Mississippi River, and the stand is composed chiefly of white pine, long-leaf and short-leaf pine, white oak, red oak, chestnut, basswood, birch, white ash, cypress, and other mixed hardwoods.

Although it is impossible to state accurately the amount of the more important species, yet it is estimated that the stand is composed of 30 per cent western yellow pine, 20 per cent Douglas fir, 10 per cent lodgepole pine, 7 per cent white fir, 5 per cent Engelmann spruce, 5 per cent western hemlock, 5 per cent cedar, 3 per cent tamarack, 3 per cent sugar pine, and 12 per cent of other species. Since the mixed hardwoods form such a small part of the total stand, they have been included in the percentages for other species.

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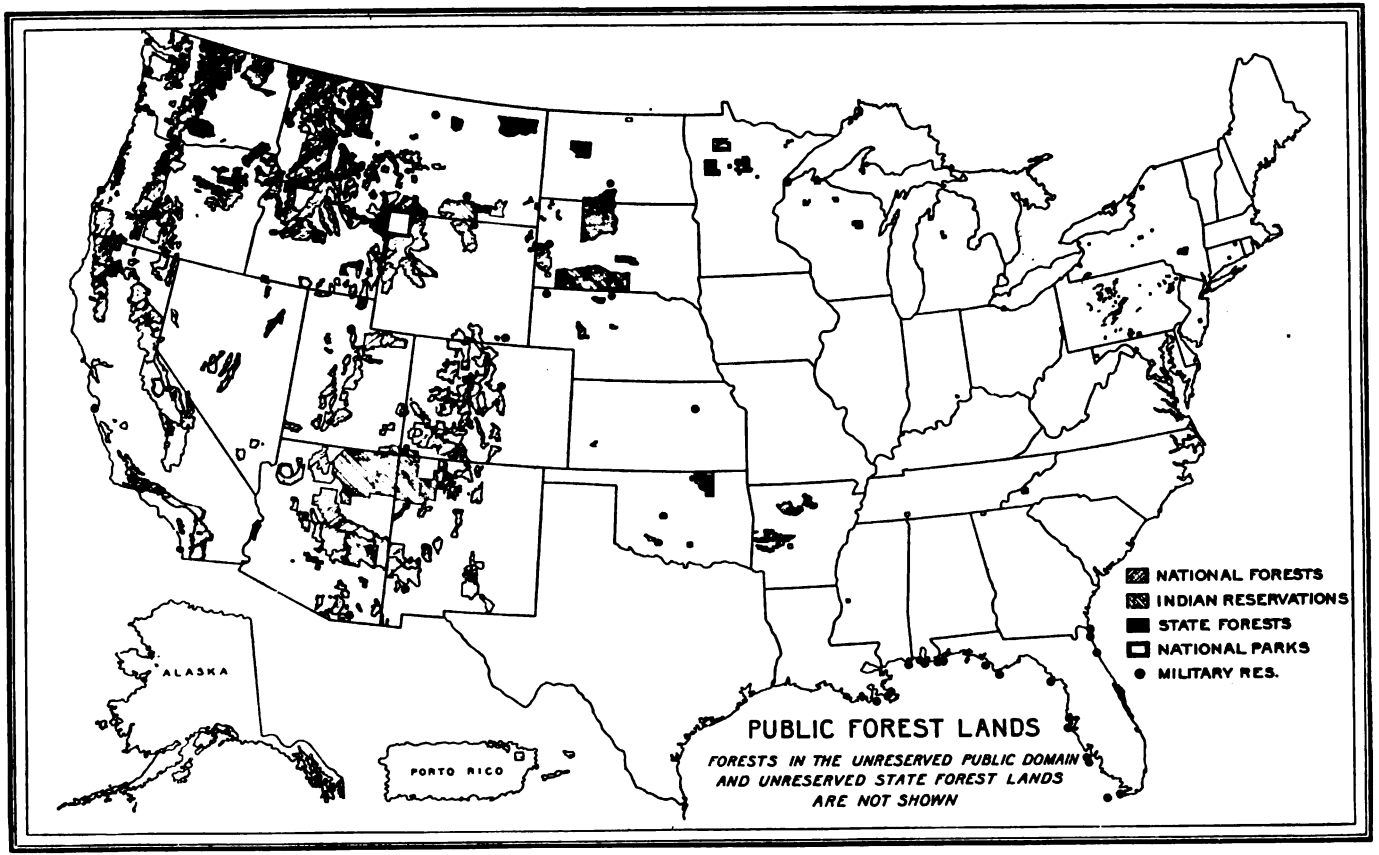

FIG. 2.

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Generally speaking, the quality of the timber in the possession of the Federal Government compares unfavorably with that in the possession of large companies and corporations. This is easily accounted for, since a large part of the unappropriated area lies at high altitudes, which are unsuited for the best growth and development of the several species.

The national forests comprise a merchantable timber area of 75,030,000 acres and support a stand of approximately 390,000,000,000 feet b. m.

The Indian reservations comprise a merchantable timbered area of 10,541,900 acres and contain approximately 34,000,000,000 feet b. m. On the whole, the timber on Indian reservations consists chiefly of yellow pine, piñon, and juniper, and is of better quality than that in the national forests, since these reservations have been created at the lower elevations and have included land better adapted for the most favorable growth.

The merchantable area of national parks is estimated to be 2,540,000 acres and contains 10,717,000,000 feet b. m. and 343,500,000 cords of wood suitable only for fuel. The kind and quality of the timber is similar to that in national forests, since they have been created in similar regions and in large part include areas at and above timber line.

Military reservations, in so far as they contain natural timber resources, are of practically no importance, since they have a merchantable area of but a little over 69,000 acres, supporting but 198,595,000 feet b. m. and 3,900,000 cords of wood suitable chiefly for fuel. The stand is composed chiefly of longleaf and shortleaf pine, Douglas fir, white fir, and mixed hard-woods. On the whole, the several species contain but little lumber of the high grades, which renders them useless for other than fuel and rough construction material.

There are approximately 4,450,000 acres of unreserved public timber land which supports approximately 14,000,000,000 feet b. m. and an unestimated amount of cordwood. This figure seems somewhat startling when one realizes that unappropriated timber land is not only subject to entry but is very much sought after on account of the diminishing supply and a corresponding increase in stumpage prices, yet it must be understood that the areas supporting this timber are in many instances so surrounded by patented land that a claim would be practically worthless for lumbering purposes, while in other cases the tracts are either too inaccessible or are of insufficient size to attract the average claimant. Since these timbered areas have thus far been rejected by claimants it follows naturally enough that this is practically the cull of the Government's national timber resources. The stand is open, scattered, and scrubby for the most part, and consists chiefly of the poorer quality of Douglas fir, hemlock, white fir, juniper, piñon, cedar, and lodgepole pine.

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TABLE 1.—*Estimated amount of standing timber in the possession of the Federal Government.*

State.	National forests.	Indian reservations.	National parks.	Military reservations.	Unreserved public lands.	Total.
	M feet b. m.	*M feet b. m.*	*M feet b. m.*	*M feet b. m.*	*M feet b. m.*	*M feet b. m*
Alabama	.....	.....	.....	1,500	50,000	51,500
Arizona	6,500,000	5,000,000	.....	50,000	.....	11,550,000
Arkansas	1,800,000	.....	.....	.....	634,000	2,434,000
California	94,800,000	3,500,000	8,000,000	.....	3,216,000	109,516,000
Colorado	12,200,000	.....	.....	.....	1,200,000	13,400,000
Florida	.....	.....	.....	8,400	80,000	88,400
Georgia	.....	.....	.....	4,100	.....	4,100
Idaho	34,600,000	2,000,000	.....	.....	2,000,000	38,600,000
Indiana	.....	.....	.....	75	.....	75
Kansas	.....	.....	.....	4,640	.....	4,640
Louisiana	.....	.....	.....	.....	55,000	55,000
Maine	.....	.....	.....	220	.....	220
Maryland	.....	.....	.....	510	.....	510
Michigan	.....	.....	.....	.....	36,000	36,000
Minnesota	.....	3,200,000	.....	.....	500,000	3,700,000
Mississippi	.....	.....	.....	.....	21,000	21,000
Missouri	.....	.....	.....	.....	13,000	13,000
Montana	35,900,000	2,400,000	.....	12,000	1,200,000	39,512,000
Nebraska	.....	.....	.....	.....	10,000	10,000
Nevada	75,000	.....	.....	.....	100,000	175,000
New Mexico	11,200,000	1,700,000	.....	40,000	800,000	13,740,000
New York	.....	.....	.....	570	.....	570
North Carolina	.....	.....	.....	30	.....	30
Oklahoma	18,000	4,000,000	.....	.....	.....	4,018,000
Oregon	90,075,000	3,900,000	562,000	600	2,500,000	97,037,600
South Dakota	2,256,000	75,000	.....	.....	443,000	2,774,000
Utah	5,940,000	14,000	.....	.....	300,000	6,254,000
Virginia	.....	.....	.....	50	.....	50
Washington	89,954,000	6,100,000	1,475,000	75,000	672,000	98,276,000
Wisconsin	.....	2,000,000	.....	.....	8,000	2,008,000
Wyoming	4,700,000	200,000	680,000	900	.....	5,580,900
Total	390,018,000	34,089,000	10,717,000	198,595	13,838,000	448,860,595

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TABLE 2.—*Estimated area of merchantable saw timber held by the Federal Government.*

State.	National forests.	Indian reservations.	National parks.	Military reservations.	Unreserved public lands.	Total.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Alabama				1,700	25,000	26,700
Arizona	5,000,000	3,000,000		15,400		8,015,400
Arkansas	916,000			780	317,000	1,233,780
California	14,000,000	209,000	500,000	517	804,000	15,513,517
Colorado	6,310,000		30,000		400,000	6,740,000
Florida				2,241	40,000	42,241
Georgia				1,270		1,270
Idaho	8,964,000	190,000			500,000	9,654,000
Illinois				200		200
Indiana				588		588
Iowa				184		184
Kansas				4,800		4,800
Louisiana				355	22,000	22,355
Maine				105		105
Maryland				315		315
Michigan		15,500			30,000	45,500
Minnesota	147,000	800,000			300,000	1,247,000
Mississippi					8,500	8,500
Missouri				1,708	5,000	6,708
Montana	8,000,000	655,000		1,500	300,000	8,956,500
Nebraska				7,500	20,000	27,500
Nevada	75,000					75,000
New Jersey				1,357		1,357
New Mexico	5,000,000	600,000		8,000	400,000	6,008,000
New York				3,096		3,096
North Carolina				1,340		1,340
North Dakota		20,000	600			20,600
Oklahoma	18,000	2,000,000	200			2,018,200
Oregon	10,700,000	915,000	140,000	340	546,000	12,301,340
South Carolina				50		50
South Dakota	800,000	75,000	3,500	65	443,000	1,321,565
Tennessee			4,993			4,993
Texas				1,710		1,710
Utah	3,000,000	13,400			200,000	3,213,400
Vermont				20		20
Virginia				27		27
Washington	7,600,000	1,694,000	126,720	13,981	84,000	9,518,701
Wisconsin		315,000			4,000	319,000
Wyoming	4,500,000	40,000	[a] 1,734,000			6,274,000
Total	75,030,000	10,541,900	2,540,013	69,149	4,448,500	92,629,562

[a] Includes small portions of the Yellowstone in Montana and Idaho.

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FOREST PRODUCTS.

By R. S. KELLOGG,
United States Forest Service.

The annual value of the forest products of the United States at the present time is approximately $1,280,000,000. The principal items are shown below; the value in every case is stated in round numbers and is estimated at the point of production. Except where otherwise specified, all statistics given in this paper are based upon data collected by the Bureau of the Census and the Forest Service.

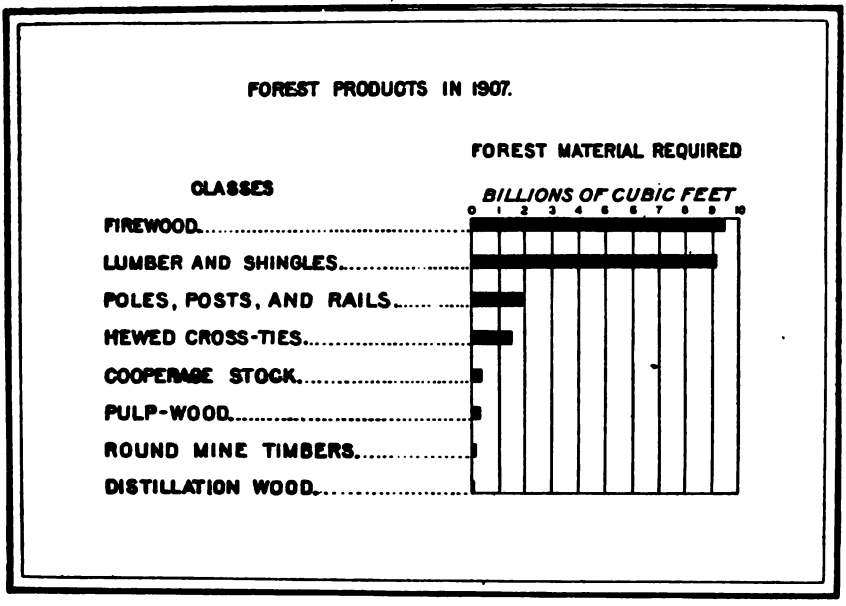

FIG. 1.

Product.	Value.	Product.	Value.
Lumber, shingles, and lath	$750,000,000	Pulp wood	$20,000,000
Firewood	250,000,000	Tanbark and extracts	15,000,000
Poles, posts, and rails	100,000,000	Round mine timbers	10,000,000
Hewed cross-ties	60,000,000	Miscellaneous	10,000,000
Cooperage stock	35,000,000		
Naval stores	30,000,000	Total	1,280,000,000

Nearly three-fifths of the total value of our forest products are made up of lumber, shingles, and lath, and a little less than one-fifth of firewood. No other group of products contributes as much as 10 per cent of the total.

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The quantity of forest material required for these products under present conditions of logging and manufacturing is shown graphically in figure 1. The total exceeds 23,000,000,000 cubic feet. Of this, firewood takes about two-fifths, lumber and shingles slightly less, posts, poles, and rails about one-twelfth, and hewed cross-ties about one-sixteenth; relatively small quantities compared with the total cut of forest material required for other products.

LUMBER.

The cut of lumber, by kinds, in 1907, is shown graphically in figure 2, the total being 40,256,000,000 board feet. Yellow pine was in the lead, with 32.8 per cent of the total; Douglas fir ranked second,

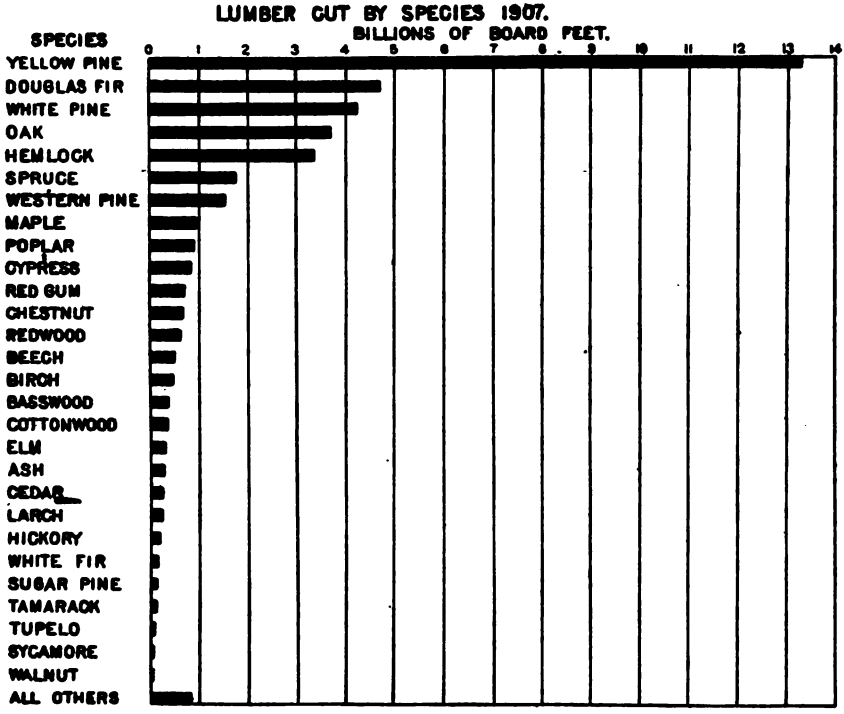

FIG. 2.

with 11.8 per cent; white pine third, with 10.4 per cent; oak, fourth, with 9.2 per cent; and hemlock fifth, with 8.4 per cent. Spruce and western pine furnished 4.3 and 3.8 per cent, respectively. These seven woods are the only ones from which over a billion feet of lumber are annually produced, and, taken together, they furnish more than four-fifths of our annual lumber supply.

The softwoods as a group supplied 77 per cent of the lumber cut in 1907, and the hardwoods 23 per cent. The softwood cut, therefore was nearly three and one-half times as great as the hardwood cut. Though there was an increase of over 14 per cent in the total

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lumber production from 1900 to 1907, this was due chiefly to very heavy increases in the leading soft woods, particularly yellow pine and Douglas fir. At the former date the hardwoods supplied nearly 25 per cent of the total. During the seven years the output of yellow pine increased 36.8 per cent, that of western pine 61.7 per cent, that of cypress 52.8 per cent, that of redwood 58 per cent, and that of Douglas fir 173.4 per cent. These far more than counterbalanced the decrease of 45.8 per cent in white pine. On the other hand, the cut of the two leading hardwoods, oak and yellow poplar, decreased 16.2 per cent and 22.6 per cent, respectively, during this period. Remarkable increases took place in the output of some of the minor hardwoods, the gain in maple, for instance, being 48.4 per cent, in red gum 141.5 per cent, and in chestnut 215.5 per cent.

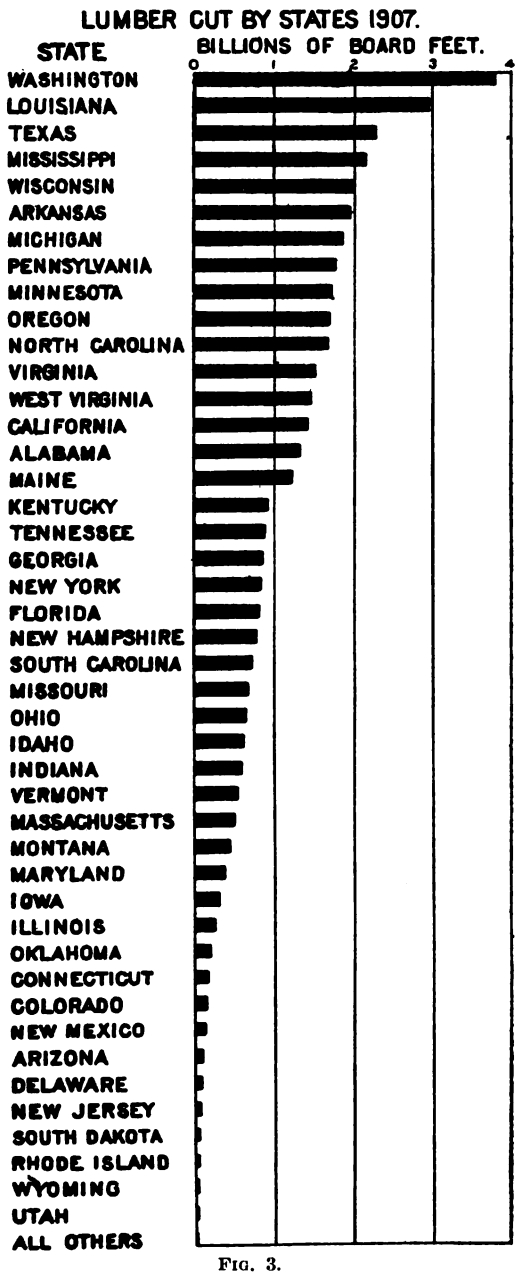

FIG. 3.

The lumber cut by States in 1907 is shown in figure 3. Washington, which ranked first, supplied 9.4 per cent of the total; Louisiana came second, with 7.4 per cent; Texas third, with 5.5 per cent; Mississippi fourth, with 5.2 per cent; and Wisconsin fifth, with 5 per cent. These five States are the only ones which cut two billion or more feet of lumber each in 1907, and taken together they furnished nearly one-third of the total production.

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The relative production of lumber in ten States in 1880 and 1907 is shown in figure 4. In 1880 these States furnished 53.8 per cent of the total cut, and in 1907, 52.4 per cent, practically equal proportions, but the changes which have occurred in the output of individual States are most striking. Michigan, for example, furnished 23 per cent of the total in 1880, and but 4.5 per cent in 1907; Louisiana supplied but 0.7 per cent of the total in 1880, and 7.4 per cent in 1907; Washington cut but 0.9 per cent of the total in 1880, and 9.4 per cent in 1907. This diagram shows in vivid fashion the manner in which, with the cutting out of the virgin timber in the North and East, we have turned to the forests of the South and West for our lumber.

Figure 5 shows graphically the lumber production of the United States at census dates, from 1850 to 1907. The cut in 1907 was eight times that in 1850, and three times that in 1870. Notwithstanding

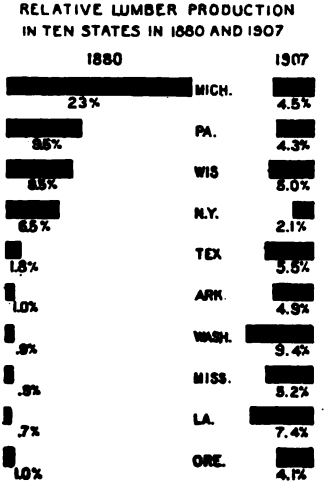

FIG. 4.

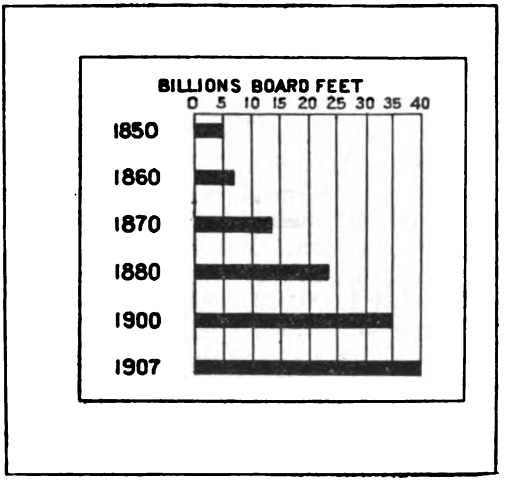

FIG. 5.

the introduction of substitutes for lumber, our use of it has steadily increased up to the present time, the per capita consumption in 1850 being but 215 board feet, while in 1907 it was 470 board feet.

SHINGLES.

Many woods are used to some extent for shingles, but the market is dominated by cedar shingles, of which there are two kinds, the white cedar, or arbor-vitæ of the northeastern and Lake States, and the so-called "red cedar," or giant arbor-vitæ of the Pacific coast. Of the total production of 11,824,475,000 shingles in 1907, the western cedar supplied over three-fifths and the eastern cedar about one-tenth. Ten per cent of the shingles manufactured that year were of cypress, and 7 per cent and 5 per cent, respectively, of redwood and yellow pine. Much more cedar is used for shingles than for other purposes, while with other woods shingles are frequently a by-product of lumber manufacturing.

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LATH.

Lath are usually a by-product of lumber manufacturing, and so do not of themselves constitute an additional drain upon the forests. While some lath are made from nearly every wood that is cut into lumber, the bulk of the 3,663,000,000 lath manufactured in 1907 was of white pine, yellow pine, hemlock, Douglas fir, spruce, and cypress.

FIREWOOD.

It is estimated that approximately 100,000,000 cords of wood, exclusive of mill waste, are used annually for fuel in the United States. The bulk of this is, of course, used for domestic purposes upon farms in the regions where wood is relatively cheap and abundant and coal difficult to obtain or high in price. A great deal of wood is used for fuel everywhere except on the Great Plains, where the almost utter absence of timber makes its use impossible. Much of it is cut from farmers' wood lots, and much of it is timber which has little value for other purposes. On the other hand, it is not uncommon to find good hard-wood timber which could be used for lumber or otherwise cut into firewood.

POLES, POSTS, AND RAILS.

Some 3,500,000 round poles, exceeding 20 feet in length, are used annually by telegraph, telephone, and other electric companies. Over three-fifths of these poles are of cedar and more than one-fourth of them of chestnut. Relatively small amounts of pine, cypress, and redwood poles are also used.

Probably 1,000,000,000 fence posts and rails are used annually upon the farms and ranches in the United States. While the cedar posts of the Lake States are shipped long distances, most of the posts and practically all of the fence rails are cut in the locality where they are used. Consequently, the timber of which they consist varies greatly, the effort always being, of course, to cut the kind that is the most durable. Wherever it grows, chestnut is a favorite wood for both posts and rails. Many posts are made from young, round timber. Rails are generally made from straight timber, of larger size, which splits well, and many posts are also split.

HEWED CROSS-TIES.

The steam and electric railway companies of the United States purchased more than 153,000,000 cross-ties in 1907, over three-fourths of which were hewed. Since sawed cross-ties are classed as lumber, they are not discussed here. The oaks, and chiefly the white oaks, supply over 45 per cent of the hewed ties, and the cutting of hewed ties from young oak trees is, with the exception of lumber, the most serious drain upon our oak forests. Over 22 per cent of the hewed cross-ties were supplied by the southern pines, about 7 per cent by cedar, and about 5 per cent by chestnut. Spruce, tamarack, western hemlock, and redwood are used in lesser quantity for hewed ties.

PULP WOOD.

Over 3,000,000 cords of domestic pulp wood were used in 1907, and in addition some 925,000 cords were imported from Canada. Of the

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domestic pulp wood, nearly three-fifths were spruce and almost one-fifth hemlock. The bulk of the remainder was poplar, with small quantities of several other woods. Nearly as much spruce is used for pulp as for lumber.

COOPERAGE STOCK.

Cooperage stock is of two distinct classes, tight and slack. While the production of the former is much less in quantity, it requires much higher grade timber. In 1907 there were manufactured 385,232,000 tight staves and 27,692,994 sets of tight heading. The slack cooperage output amounted to 1,175,977,000 staves, 106,074,000 sets of heading, and 490,570,000 hoops. Probably 90 per cent of the tight cooperage stock required the best quality of white oak for its production. A large number of woods are used for slack staves and heading, the most important being red gum, pine, elm, beech, and maple. Because of its strength and toughness, little but elm is used for hoops. Probably as much elm is used for staves and hoops as for lumber.

TANBARK AND EXTRACTS.

The tanneries of the United States used nearly 1,200,000 cords of hemlock and oak bark and more than 400,000 barrels of tanning extracts made from domestic bark and wood in 1907. Two-thirds of the bark was hemlock, and the balance oak. Two-thirds of the extract was made from chestnut wood, and most of the remainder from hemlock and oak bark. Nearly 130,000 cords of hemlock and oak bark were used in making extract.

In the earlier days of the tanning industry a great deal of hemlock was cut solely for its bark and the wood was left to rot in the woods. This was also true to a lesser extent of oak. These practices are not general at the present time, however. The manufacture of tanning extract from chestnut wood has increased rapidly within recent years, and at least 250,000 cords of wood were used for this purpose in 1907. There have also been marked increases in the importation of tanning materials, the most striking being that of the wood and extract of quebracho, a South American tree. Over 290,000 barrels of quebracho extract were used by the tanneries of the United States in 1907.

ROUND MINE TIMBERS.

Data gathered by the Forest Service and the Geological Survey in 1905, upon the use of timber in mines, show that the annual consumption of round mine timbers exceeds 165,000,000 cubic feet, and that hard woods constitute more than half the total. Like the making of hewed cross-ties, the cutting of round mine timbers takes large quantities of young timber, and in many localities constitutes a serious drain upon the forests.

NAVAL STORES.

In 1908 there were produced 36,000,000 gallons of turpentine and 4,000,000 barrels of rosin, of which Georgia and Florida supplied two-thirds. About one-half of the product is exported.

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While the production of naval stores does not necessarily destroy the forests, the methods so far used in the majority of the turpentining operations, coupled with subsequent fires and windstorms, have resulted in the destruction of not less than 20 per cent of the forests worked.

MISCELLANEOUS PRODUCTS.

There are included under this heading such forest products as maple sugar and sirup, timber which is exported in the log, and wood used for distillation, whose total annual value is easily $10,000,000. More than 1,280,000 cords of wood were used for distillation in 1907. With the exception of about 60,000 cords of pine, this wood consisted of hard woods, chiefly birch, beech, and maple. No detailed information is available upon either the kind or quantity of logs exported, though the reports of the Bureau of Statistics show their value to be more than $3,000,000. Probably more walnut is exported in the log than any other timber which is sent out in this form.

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RATE OF FOREST GROWTH.

By E. A. Ziegler,
United States Forest Service.

PRESENT TIMBER PRODUCTION.

The very existence of a problem of forest conservation is dependent upon the question of timber production. If production falls below consumption at present or threatens to in the future, the problem is very real. If the production exceeds consumption there is obviously no problem of conservation to solve. What data we have, therefore, on tree growth and wood production deserve careful study.

An idea of our present timber production requires, in the absence of records, information (1) on the rate of growth in diameter and height of the individual species composing our forests; (2) on the production per acre when a normal number of trees is present (i. e., when the land is fully stocked), and (3) on the condition for growth of the present forest. This (3) requires the classification of forest lands roughly into (*a*) nonproducing forest land which includes that covered with mature forests, as well as that not producing through lack of trees, and (*b*) the producing forest land with its present stocking, whether cut over, culled over, or burned. Applying the average growth per fully stocked area to the area of producing forest and multiplying by the average per cent of stocking would give the total growth. It is very difficult to secure definite data showing the average restocking of second-growth forests of the country, however, and on this point it may be necessary to accept expert judgment supported by studies of specific areas.

THE RATE OF GROWTH OF INDIVIDUAL SPECIES.

Studies on the rate of growth of different species giving the diameter and height at different ages have been made and are here summarized. These studies were largely made on trees cut in virgin forests, where their development under the shade of a preceding generation of trees may have been slower than if they had been given the better light conditions of a clearing or heavy culling. To what degree the changed condition of light, soil, etc., following lumbering affects subsequent growth is not definitely known,[a] though the diameter growth of individual trees is frequently increased, but often a poorer quality of material is produced. This is caused to some ex-

[a] The increased growth due to removing mature trees in a spruce forest in New York was found to be about 13 per cent for the first five years after lumbering.—"The Adirondack Spruce," page 45, Pinchot.

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tent by too few trees per acre, which reduces the acre yield in the face of faster diameter growth in the individuals.

The growth given is of course an average. White pine on lower slopes in New York is said to have an average diameter of 10.6 inches in fifty years. The largest number will be from 9 to 12 inches in diameter, though a few may be 15 inches or even more, and many trees will fall much below that figure.

The summaries are grouped in the form of regional tables:

Table 1, showing diameter and height growth in northern forests.

Table 2, showing diameter and height growth in central hard-wood forests.

Table 3, showing diameter and height growth in southern forests.

Table 4, showing diameter and height growth in Rocky Mountain forests.

Table 5, showing diameter and height growth in Pacific coast forests.

Both the common and botanical names are given, as well as the locality and so-called forest type where the measurements were made. The diameter and height at different ages follow.

Different studies made on the same species show varying rates of growth, so to avoid the bulky mass of detail a selection was made of the more representative data and the rest added in an appendix. When only one study was made, and the growth hardly seems representative of the species, note is made of it.

A study of the tables will reveal large differences in rate of growth in diameter and height between different species, but a full comparison should include the number of trees per acre also. That is, the production per acre must be the final index in determining desirable species, rather than rapidity of diameter or height growth which may be offset to some extent by the stand per acre.

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TABLE 1.—*Approximate average rate of growth for northern forests.*

Species.		Locality.	Forest type.	Age.									
				30 years.		50 years.		80 years.		100 years.		150 years.		200 years.	
Common name.	Botanical Name.			Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.
				Inches.	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
Arborvitæ	Thuja occidentalis	Michigan	Swamp	2.2	15	3.8	28	5.7	34	6.9	38	9.8	45	12.3	50
Aspen	Populus tremuloides	Maine	Mixed hardwood	6.0	45	9.4	65	12.0	76						
Basswood	Tilia americana	Michigan	do	4.5	42	8.1	51	13.2	67	15.7	72	19.1	75		
Beech [a]	Fagus atropunicea	do	do	1.8	19	3.8	35	8.0	68	10.2	73	13.6	74	16.6	75
Birch, paper	Betula papyrifera	Maine	Paper birch, Seedling	5.3	44	8.0	62	10.2	78						
		New Hampshire	Paper birch, Sprout	5.6	49	7.9	70								
Birch, yellow	Betula lutea	New York	Mixed hardwood	2.6	24	4.5	35	7.4	52	9.4	59	14.5	69	19.4	75
Elm, white	Ulmus americana	No data													
Fir, balsam	Abies balsamea	New York	Dry swamp	2.3	20	5.2	42	7.2	53	7.6	54	8.3	57		
Hemlock [a]	Tsuga canadensis	Michigan	Hemlock-hardwood	1.3	9	2.9	20	5.7	37	7.8	45	13.4	63	18.4	73
Maple, sugar [a]	Acer saccharum	do	Mixed hardwood	1.9	21	3.8	35	7.0	50	9.0	64	14.0	72		
Pine, jack	Pinus divaricata	Minnesota	Jack pine—Quality I	6.2	40	8.5	50								
Pine, red	Pinus resinosa	Wisconsin	Ravine—Quality I	5.8	45	10.3	75	15.3	90	17.6	95	22.6	103	26.1	108
Pine, white	Pinus strobus	New York	Lower slopes	5.8	42	10.6	60	16.6	82	20.0	92	26.0	106	29.8	115
		Minnesota	White and red pine	5.3	48	9.2	71	13.0	82	14.8	85	18.3	91	21.7	96
Spruce, black	Picea mariana	Minnesota	Swamp			1.1	9	2.6	17	3.0	20	4.1	26	4.7	29
Spruce, red	Picea rubra	Maine	Spruce slope	2.4	21	5.3	36	7.2	44						
Spruce, white	Picea canadensis	Minnesota	Swamp			2.3	22	4.9	41	6.0	46	9.0	60		
Tamarack	Larix laricina	do	do	2.9	32	5.0	50	6.9	62	7.8	66	11.0	75		

[a] These species were undoubtedly suppressed for some years.

NOTE.—The diameter given is 4.5 feet from the ground.

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NORTHERN FORESTS.

This region embraces New England, New York, and the lake States of Michigan, Wisconsin, and Minnesota, and part of the Appalachian highlands extending farther south. It is marked by the presence of the white pine as the principal species. Red spruce in the east, red pine in the west, and hemlock through a large part of the region are important conifers, with arborvitæ, tamarack, and jack pine of less importance. Birches, beech, elm, aspen, basswood, and maples are rather important hard woods.

In growth, white pine leads except for jack pine and aspen in the first thirty years. Red pine in Wisconsin and Minnesota seems to exceed it in that part of the range with an excellent growth. Since jack pine is a small tree when mature its growth falls off rapidly before reaching even tie size. Spruce is rather slow growing, but arborvitæ, tamarack, hemlock, and balsam fir are still slower. Aspen and basswood grow rapidly, as does paper birch under favorable conditions. Beech, sugar maple, and yellow birch are rather slow growing. The figures for beech, hemlock, and sugar maple seem to show a suppression during early life, and further studies under different conditions may show a more rapid growth, though at best they grow slowly.

CENTRAL HARD-WOOD FORESTS.

The central hard-wood forests are found mainly on the west and east slopes of the Alleghany Mountain plateau. They have been largely removed from Illinois and Indiana, so Tennessee and Kentucky show their best development at present. Yellow poplar is the most rapid-growing species and furnishes a good example of growth, as it varies under different conditions of virgin forest and second growth, the latter under very favorable conditions. Chestnut is a very rapid grower and has next place. Since valuable for posts, poles, and ties in small sizes, it holds forth great promise to the wood producer. Red oak, black oak, and white oak follow in the order named when grown from sprouts. Hickory approaches white oak in growth.

Farm timber plantations in Illinois show an excellent growth for silver maple for fuel, catalpa and European larch for posts and poles, and black walnut, under an eighty to one hundred year rotation, for timber.

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TABLE 2.—*Approximate average rate of growth for central hardwood forests.*

Species.		Locality.	Forest type.	Age.											
				30 years.		50 years.		80 years.		100 years.		150 years.		200 years.	
Common name.	Botanical name.			Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.
				Inches.	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
Catalpa [a]	Catalpa speciosa	Illinois	Farm plantations	9.0	45										
Chestnut	Castanea dentata	Maryland	Hardwood, seedling	6.0	33	11.2	64	17.2	84	20.1	91				
			Hardwood, sprout	9.3	57	13.4	77	18.0	90	19.8	93				
Mockernut (hickory)	Hicoria alba	Mississippi	Mixed hardwood	3.3		6.0		10.5		13.3		20.0		26.0	
Larch, European. [a]	Larix europea	Illinois	Farm plantations	8.8	45										
Locust, black	Robinia pseudacacia	Kentucky	Close to open stands	7.1	36	11.5	44								
Maple, silver [a]	Acer saccharinum	Illinois	Farm plantations	9.0	55										
Oak, black	Quercus velutina	Tennessee	Mixed hardwood, seedling.	4.8	35	7.8	52	12.0	61	14.2	68	18.3	78	22.0	85
		Kentucky	Mixed hardwood, sprout.	6.9	53	11.3	75	13.8	80	14.4	81				
Oak, chestnut	Quercus prinus	Tennessee	Mixed hardwood, seedling.	3.3	20	5.6	35	8.8	45	11.0	53	16.0	66	21.0	76
Oak, red	Quercus rubra	Kentucky	Mixed hardwood, sprout.	7.6	56	12.4	76	16.4	86						
Oak, white	Quercus alba	Tennessee	Mixed hardwood, seedling.	3.5	27	5.8	34	9.0	56	11.2	65	17.0	82	22.2	92
		Kentucky	Mixed hardwood, sprout.	5.6	40	8.7	57	11.2	69	12.2	72	14.4	77		
Walnut, black [a]	Juglans nigra	Illinois	Farm plantations (moist soil).	8.0	40	12.0	60								
Yellow poplar	Liriodendron tulipifera	Tennessee	Cove (virgin forest)	5.0	39	8.7	60	13.7	81	17.0	90	24.0	100	28.2	105
		Virginia	Second growth in open—Quality I—seedling.	9.7	64	15.2	83								

[a] These species were grown in plantations on farm land, and have a correspondingly faster growth than the other forest-grown species. (See For. Ser. Cir. 81.)

NOTE.—The diameter given is 4.5 feet from the ground.

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SOUTHERN FORESTS.

Southern forests include mainly the southern pine belt and the hard woods found along the rivers and coast, where cypress adds another important conifer.

The three principal southern pines, longleaf, shortleaf, and loblolly, make up the bulk of the southern forests and should play an important part in the future timber production of the country. Loblolly grows very rapidly and will produce a good crop of ties in forty years. Longleaf and shortleaf are both much slower growers, though longleaf gives excellent reproduction where fires do not run. Shortleaf occasionally exceeds longleaf in growth. The restocking of the cut-over pine forests is especially deficient on account of fire. Cypress makes a rather slow growth at first, but increases it to a considerable age, so that for a long period rotation it exceeds many other species. The natural reproduction is almost entirely wanting, however.

Eastern red cedar in locations between the pine and southern Appalachian hard-wood belts shows a fair growth and promises well for management.

The bottom-land hard woods contain several species of almost phenomenal growth. Cottonwood here shows a greater growth than any other native American species, producing timber of saw size at thirty to forty years of age. Red gum and white and green ash also do remarkably well on the lowlands.

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TABLE 3.—*Approximate average rate of growth for southern forests.*

Species.		Locality.	Forest type.	Age.											
				30 years.		50 years.		80 years.		100 years.		150 years.		200 years.	
Common name.	Botanical name.			Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.
				Inches.	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
Ash, white	Fraxinus americana	Arkansas	Bottom land	7.8	67	12.1	90	17.5	103	20.3	106	.....	.....	.....	.....
Cedar, eastern red.	Juniperus virginiana	Alabama	"Forest grown"	5.0	35	9.0	50	14.0	59	.....	.....	.....	.....	.....	.....
Cottonwood	Populus deltoides	Mississippi	Bottom land (sprout?)	21.7	126	30.4	143	38.4	152	.....	.....	.....	.....	.....	.....
Cypress, bald	Taxodium distichum	Maryland	Swamp	3.9	31	7.8	53	15.2	82	20.5	95	35.0	107	.....	.....
Gum, black	Nyssa sylvatica	No data.													
Gum, red	Liquidambar styraciflua.	South Carolina	Bottom land	11.2	87	16.8	106	23.4	116	26.9	120	34.2	125	.....	.....
Pine, cuban	Pinus heterophylla	do	Lowland pine type	6.2	44	10.4	67	15.0	86	17.3	93	21.7	102	25.0	105
Pine, loblolly	Pinus tæda	do	Pine type	10.0	59	15.9	86	21.5	104	24.5	111	30.7	122	.....	.....
Pine, longleaf	Pinus palustris	do	do	3.0	29	6.7	52	12.4	78	15.5	86	20.0	95	23.6	100
Pine, scrub	Pinus virginiana	Maryland	Pure stand—Dom.	6.5	46	8.9	63	.....	.....	.....	.....	.....	.....	.....	.....
Pine, shortleaf	Pinus echinata	Arkansas	Pine type	4.2	35	7.5	53	11.9	72	14.6	81	19.8	93	23.4	100

NOTE.—The diameter given is 4.5 feet from the ground.

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ROCKY MOUNTAIN FORESTS.

The Rocky Mountain forests are entirely coniferous when the important species are considered.

Western yellow pine is the predominating species, and, excepting possibly Douglas fir, is the most rapid-growing species.

Lodgepole pine grows rather slowly, though it reproduces with a dense stand.

Engelmann spruce shows very slow growth in the study in Colorado.

No growth data have been collected on western larch, white fir, or silver pine—other important trees of the region.

The central fact in tree growth in this section is its slowness, which contrasts sharply with the rate of growth on the Pacific coast.

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TABLE 4.—*Approximate average rate of growth for Rocky Mountain forests.*

Species.		Locality.	Forest type.	Age.											
Common name.	Botanical name.			30 years.		50 years.		80 years.		100 years.		150 years.		200 years.	
				Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.
				Inches.	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
Fir, alpine	Abies lasiocarpa	No data													
Fir, Douglas	Pseudotsuga taxifolia	Idaho	Fir slope—Quality I	1.6	8	5.9	35	12.3	63	15.6	72	21.1	86	24.9	93
Fir, white	Abies concolor	No data													
Larch, western	Larix occidentalis	do													
Pine, lodgepole	Pinus contorta	Montana	Lodgepole slope	4.0	40	6.6	60	9.6	70	11.2	73	14.0	76		
Pine, silver	Pinus monticola	No data													
Pine, western yellow	Pinus ponderosa	Arizona	Pure stand	4.3	18	8.1	30	12.0	43	14.0	48	18.7	61	21.6	68
Spruce, Engelmann	Picea engelmanni	Colorado	Dry slope			1.6		4.3		6.2		10.1	60	13.7	75

NOTE.—The diameter given is 4.5 feet from the ground.

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PACIFIC COAST FORESTS.

The important species are here again all conifers, though with a growth greatly exceeding that of the Rocky Mountains. The Douglas fir produces an excellent growth and holds much promise for the future. Redwood in California equals or exceeds the fir in growth, with an added advantage of reproducing from stump sprouts. Western yellow pine ranks third in growth among the important species, though it is finally overtaken by sugar pine. Western hemlock holds fifth place.

No study of growth has been made on western red cedar or the less important spruce, firs, etc., except on the white fir in Siskiyou County in northern California, which reveals a rather slow growth in this locality. Western yellow pine and Douglas fir furnish a comparison between the Rocky Mountain and coast regions.

Eucalyptus globulus, or blue gum, introduced into southern California from Australia, grows at the rate of almost an inch in diameter and 5 feet or more in height per year from the seed, and sprouts exceed even this phenomenal growth. As a wood producer in favorable localities free from frost it has no equal.

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TABLE 5.—*Approximate average rate of growth for Pacific coast forests.*

Species.		Locality.	Forest type.	Age.									
				30 years.		50 years.		80 years.		100 years.		150 years.		200 years.	
Common name.	Botanical name.			Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.
				Inches.	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
Cedar, western red.	Thuya plicata	No data													
Fir, Douglas [a]	Pseudotsuga taxifolia.	Washington	Fir-hemlock (virgin)	7.4	48	13.7	80	20.5	118	24.3	138	31.3	180	37.4	208
			Fir-hemlock (second growth).	10.5	68	14.6	114								
Fir, white	Abies concolor	California	Plateau, slope, and bottom.	0.7	8	3.9	24	9.0	57	12.2	76	19.5	111	26.0	136
Gum, blue [b]	Eucalyptus globulus	Southern California.	Plantations—Quality I—seedlings.	28.0	140										
Hemlock, western.	Tsuga heterophylla	Washington	Pure hemlock (virgin).	3.8	35	7.6	55	12.4	93	15.2	110	21.6	142	27.6	165
			Pure hemlock (second growth).	8.2	62	12.6	96	15.7	122	17.1	132				
Pine, sugar	Pinus lambertiana	California	Mixed slope (Sierras)	4.1	22	7.8	39	14.4	70	18.7	92	28.2	134	32.4	144
Pine, western yellow.	Pinus ponderosa	do	Mixed sugar pine	7.1	35	12.2	61	17.8	87	20.9	101	26.5	121	29.7	130
Redwood	Sequoia sempervirens	do	Moist flat-sprout	10.7	71	14.5	95								

[a] The diameter given is 4.5 feet from the ground, except for Douglas fir, which is for a stump height a little higher than 4.5 feet.
[b] An exotic introduced from Australia and widely planted for wind-break and fuel purposes in southern California.

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From the preceding growth summary and the tables of the appendix the following table has been derived, estimating the time required to produce different wood crops. The periods of time are again averages often derived from growth in virgin forests and may be lowered slightly under the best second-growth conditions.

The average diameter at which timber may be best utilized for posts is assumed to be 6 inches, which means a range possibly of from 4 to 8 inches. Among the species commonly used in the East, chestnut (twenty years) is very rapid growing, but is equaled by catalpa in the Middle West farm plantations. White oak (thirty-five years) and eastern red cedar (thirty-five years) have a fair rate of growth. Northern white cedar, or arborvitæ (eighty years), grows exceedingly slowly. When the use of preservatives becomes more common, such species as red and black oaks (twenty-five years), loblolly, jack, red and white pines (twenty to thirty-two years), and yellow poplar (twenty years) may be used to good advantage, since they have rapid growth.

In the West data for cedar are wanting. Redwood (twenty years), however, will be a good producer. Assuming preservative treatment, yellow pine and Douglas fir (twenty-five years) promise well toward the coast, as does lodgepole pine (forty years) in the Rockies, for which the large number of trees per acre offset somewhat its slower growth.

TABLE 6.—*Time required to produce different wood crops.*

Species.	Locality.	Average diameter, 6 inches (posts).	Average diameter, 8 inches (handle, extract, pulp, spool, or fuel wood, props).	Average diameter, 11 inches (ties).	Average diameter, 14 inches (poles and piles).	Average diameter, 18 inches (saw timber).
Northern forests.		*Years.*	*Years.*	*Years.*	*Years.*	*Years.*
Arbor vitæ	Michigan	80	.....	150	200	.....
Aspen	Maine	.....	40	.....	.....	.....
Basswood	Michigan	.....	50	.....	.....	130
Beech [a]	do	.....	80	100	.....	200
Birch, paper	Maine	.....	50	.....	.....	.....
Birch, yellow	New York	.....	85	.....	.....	180
Fir, balsam [a]	do	.....	100	.....	.....	.....
Hemlock [a]	Michigan	.....	100	130	.....	.....
Maple, sugar [a]	do	.....	90	.....	.....	200
Pine, jack	Minnesota	30	45	.....	.....	.....
Pine, red	Wisconsin	32	40	55	75	100
Pine, white	New York	32	40	55	.....	90
Spruce, red	do	.....	85	.....	.....	.....
Tamarack	Minnesota	65	.....	150	.....	.....
Central hardwood forests.						
Chestnut [b]	Maryland	20	25	40	55	85
Hickory (mockernut) [b]	Mississippi	50	65	.....	.....	135
Oak, black	Kentucky	25	35	50	.....	130
Oak, red	do	25	30	45	.....	100
Oak, white	do	35	45	80	.....	160
Poplar, yellow	Tennessee, virgin forest.	.....	45	.....	.....	110
Poplar, yellow [b]	Virginia, second growth.	20	25	.....	.....	.....

[a] Species tolerant of shade which should show better results in second growth.
[b] Species growing under favorable conditions when measured.

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TABLE 6.—*Time required to produce different wood crops*—Continued.

Species.	Locality.	Average diameter, 6 inches (posts).	Average diameter, 8 inches (handle, extract, pulp, spool, or fuel wood, props).	Average diameter, 11 inches (ties).	Average diameter, 14 inches (poles and piles).	Average diameter, 18 inches (saw timber).
Farm timber plantations.		*Years.*	*Years.*	*Years.*	*Years.*	*Years.*
Catalpa [a]	Illinois	20				
Larch, European [a]	do	23				
Maple, silver [a]	do		25			
Walnut, black [a]	do	25	35			
Cottonwood [a]	Nebraska		18			
Southern forests.						
Ash, white	Arkansas		30	45		85
Cedar, eastern red	Alabama	35	45	65		
Cottonwood	Mississippi		15			30
Cypress	Maryland	40		65	75	90
Gum, red	South Carolina			30		55
Pine, loblolly	do	20	25	40	55	70
Pine, longleaf	do			75	100	130
Pine, scrub	Maryland	30	40	70		
Pine, shortleaf	Arkansas		55	75	100	130
Rocky Mountain forests.						
Fir, Douglas	Idaho	50	60	75		125
Pine, lodgepole	Montana	45		100		
Pine, western yellow	Arizona	40	50	75		150
Spruce, Engelmann	Colorado	95		150		
Pacific coast forests.						
Fir, Douglas	Washington	25	35	45	50	75
Fir, white	California		75			140
Hemlock, western	Washington		50	70		125
Pine, sugar	California	40	50	65		100
Pine, western yellow	do	25	35	45	55	80
Redwood [b]	do	20	25	35	50	70

[a] Species growing under favorable conditions when measured.
[b] Species tolerant of shade which should show better results in second growth.

For handle and vehicle wood (6 to 10 inch trees) white and green ash in the southern valleys and bottoms promises well (thirty years). Hickory requires sixty-five years, though it may be used in smaller sizes at an earlier age. Hard or sugar maple in second growth should be ready earlier than the ninety years indicated by virgin forests. White oak from sprouts will reach 8 inches in about forty-five years.

For pulp wood (6 to 10 inch trees) red spruce will require about eighty-five years. Hemlock and balsam fir are still slower growing. Cottonwood in southern bottoms seems worth serious consideration as a future source of supply by planting, since studies thus far made show it will produce 6 to 10 inch pulp wood in fifteen years in those localities. Aspen in the North in forty years is a better grower than spruce, unless the fewer trees per acre will offset the better growth. Yellow poplar in the South (Virginia) in second growth often produces wood of pulp-wood size in twenty-five years, yielding in that period 23 to 35 cords per acre if the trees are closely spaced. If methods of utilizing the pines for pulp are improved, loblolly pine (twenty-five years) and jack and scrub pines (forty years) might receive some attention.

Chestnut extract wood may be produced in twenty-five years. Paper-birch spool wood in fifty years, for 6 to 10 inch wood.

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For mine props red oak requires thirty years, black oak thirty-five years, and white oak forty-five years; red pine forty years, loblolly pine twenty-five years; western yellow pine in the Rocky Mountains fifty years; Douglas fir and western yellow pine on the west coast thirty-five years. For other species see Table 6.

Railroad ties of white cedar (arbor vitæ) require as much as one hundred and fifty years to produce them in the cedar swamps of the North. Tamarack requires a similar period. Eastern hemlock is also very slow growing in virgin forests, requiring one hundred and thirty years. Beech does a little better, with one hundred years. These species may be bettered somewhat in second growth, but can not approach chestnut, which in forty years will produce good ties; red oak in forty-five years; white oak will require eighty years, though in favorable localities from sprouts possibly a little less time will be required. Mixed oaks in sixty years will produce from 100 to 200 ties per acre. Red and white pine do very well in a fifty-five-year period, but loblolly pine will reach tie size in forty years and produce 160 to 400 ties per acre, according to the number of trees present at this time. Longleaf pine will require seventy-five years to produce a crop of ties; cypress sixty-five years. Red gum, if treated and properly handled, will make a good tie, and will produce a crop in thirty to thirty-five years in southern lowlands, where it is native.

Rocky Mountain species grow slowly, with little chance of tie production in less than an average of seventy-five years, except in very favorable localities. On the Pacific coast Douglas fir and western yellow pine will produce ties in forty-five years in favorable locations, and redwood sprouts in even less time.

For poles and piles chestnut leads in the East. Loblolly pine does excellently and red pine fairly in Minnesota. On the Pacific coast Douglas fir, western yellow pine, and redwood produce good-sized poles in fifty to fifty-five years. Judging from its growth in plantations in Illinois, European larch should produce poles in a short period. Eucalyptus globulus (blue gum) in southern California will produce material of this size in fifteen years and in even less time from sprouts in the best situations.

For saw timber an average diameter (always at 4.5 feet from the ground) of 18 inches is taken, and would mean a range of from 10 to 24 inches and a sprinkling of even larger trees. This is, of course, a smaller tree than the average of many species now cut. The future timber crops will, however, be largely composed of smaller trees, since it will not pay to wait for the large dimensions. Among the species producing timber of this average size in ninety years or less might be named white pine (ninety), chestnut (eighty-five), ash (eighty-five), cottonwood (thirty), cypress (ninety), red gum (fifty-five), loblolly pine (seventy), Douglas fir (seventy-five), western yellow pine (eighty), and redwood (seventy). Yellow poplar, red oak, sugar pine, and red pine will also, under good conditions, fall under this mark. The other species studied are slower growing.

ACRE YIELDS.

The production of a number of species in fully stocked (dense) natural second-growth stands may be seen from the following tables. Since the average second-growth forest of the country is clearly not

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as dense as it should be, and these figures show actual production only on occasional areas, the average production will fall far below these figures. The tables show rather the possibilities under forest management. Quality II locations are selected as representing an average rather than Quality I. To reduce the cubic-foot yield to cords, divide by 90, and to reduce to board feet, Scribner rule, multiply by 3 (for 10-inch trees) or 4 (for 16-inch trees). The actual saw cut should exceed this in straight sound trees.

TABLE 7.—*White pine*[a]*—Quality II—Southern New Hampshire.*

Age.	Trees per acre.	Mean diameter.	Mean height.	Acre yield.	
	Number.	*Inches.*	*Feet.*	*Cubic feet.*	*Board feet.*
40 years	870	6.8	52	5,800	.....
50 years	510	9.0	66	7,300	20,000
60 years	380	10.7	76	8,500	25,000
70 years	310	11.9	84	9,150	30,000
80 years	260	12.9	89	10,300	35,000
90 years	220	14.5	93	11,000	41,000

[a] Data collected by L. Margolin.

White pine is seen to be one of the best timber-producing species in the forest, keeping up a high rate of increase to a considerable age. The larger number of trees per acre enable it to produce as well or better than the faster-growing loblolly pine, yellow poplar, and chestnut of the East.

TABLE 8.—*Loblolly pine in eastern Texas.*

Age.	Trees per acre.	Mean diameter.	Mean height.	Acre yield.	
	Number.	*Inches.*	*Feet.*	*Cubic feet.*	*Board feet.*[a]
20 years	405	6.1	45	2,600	6,500
30 years	185	9.5	65	3,200	7,450
40 years	150	12.4	85	3,700	9,300

[a] Herring rule.

This yield of second-growth loblolly pine (from Forest Service Bul. 64, by R. Zon) may be somewhat increased under careful management. The yield here quoted shows less than the preceding white-pine yield, due to the greater number of white pines per acre. Loblolly pine outstrips white pine in rate of growth for single trees, and in proper situations will receive strong support by southern foresters.

TABLE 9.—*Paper birch in Maine.*[a]

Age.	Mean diameter.	Mean height.	Acre yield.		
			Quantity.		6-inch diameter and over.
	Inches.	*Feet.*	*Cubic feet.*	*Cords.*	*Per cent.*
30 years	5.6	48	1,700	19	46
40 years	7.2	58	2,520	28	75
50 years	8.4	65	3,340	37	91
60 years	9.2	70	3,940	43	98
70 years	10.0	74	4,450	49	100

[a] Data collected by R. Marston.

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The table for paper birch represents a woods classification of Quality I and may be a trifle high for average well-stocked, pure birch woods. The table will be of peculiar interest to spool makers. In applying it to large areas of natural forests a large deduction must be made for deficient stocking—again rather showing the possibilities of forest management.

TABLE 10.—*Second-growth yellow poplar—Quality II—Fairfax County, Va.*[a]

Age.	Trees per acre, 5 inches and over.	Mean diameter.	Mean height.	Acre yield.		
				Trees 5 inches and over.		Trees 7 inches and over (Scribner scale).
	Number.	*Inches.*	*Feet.*	*Cubic feet.*	*Cords.*	*Board ft.*
30 years	290	7.8	60	2,750	30	5,800
40 years	255	9.0	65	3,625	40	9,650
50 years	210	10.4	70	4,100	46	11,900
60 years	165	12.0	75	4,575	51	14,200

[a] Data collected by W. W. Ashe.

The mean diameter given above for dense stands is frequently exceeded in less crowded forests, though the acre yield shows the possibilities of the species under systematic management. This species should be of considerable value to southern pulp manufacturers.

TABLE 11.—*Mixed hard-wood coppice, Stewart and Decatur counties, Tenn.*

[White and black oaks about equal in quantity.]

Age.	Trees per acre.	Acre yield.[a]
	Number.	*Cubic feet.*
30 years	700	1,708
40 years	500	1,980
50 years	355	2,160
60 years	255	2,270
70 years	180	2,370

[a] Table prepared under direction of R. Zon.

The mixed hard woods of the southern Appalachians show a better uniform reproduction than the northern pines and spruce and far better than the southern pines, since reproduction results largely from sprouts, and one or two fires will not have the serious effect of preventing all reproduction, though fires do decrease the vitality of the forest and sometimes occur frequently enough to produce barren areas.

TABLE 12.—*Blue gum (Eucalyptus globulus)—Quality II—planted in southern California.*

Age.	Acre yield.			
	Seedlings.		Sprouts.	
	Cubic feet.	*Cords.*	*Cubic feet.*	*Cords.*
5 years	1,000	11	2,265	25
10 years	2,950	33	4,110	45
15 years	4,200	46	5,270	58
20 years	5,275	58		
30 years	7,175	80		

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This species, imported from Australia, unfortunately can not be included among our important forest species, since it is confined to almost frostless regions. With its enormous and almost unheard of wood production it is playing an important role as wind-breaks and in the production of fuel in southern California, and may also furnish piles, implement wood, and other materials as it becomes better known. The yields quoted are exceeded by 50 per cent under most favorable conditions.

PRESENT AVERAGE PRODUCTION PER ACRE AND TOTAL PRODUCTION.

From the foregoing notes on the growth of the different species and the yield per acre in the infrequent fully stocked stands of second growth forest, little information can be gotten on the actual wood production throughout our forests, since growth conditions are often very unfavorable. In very old mature forests growth is offset by decay, and our millions of acres of this type of forest may for all practical purposes be regarded as nonproducing capital. Were all our forests of this class, the production per acre would be zero. Were all mature trees removed and the land all densely stocked with thrifty growth, the yield would approximate from 30 to 110 cubic feet per acre per year according to the species and locality. The actual forest represents all degrees of production between these two extremes. There are large bodies of overmature timber that are not increasing. There are small areas of pure second growth producing the maximum amount. There are culled-over areas containing mature defective trees or undesirable species mixed with second growth, areas denuded by ax and fire with no appreciable growth, and, the largest class of all, cut over and burned over lands with some growing trees, but usually not nearly as dense as the virgin forest.

To arrive at any approximation, then, of the total wood production of the country some rough classification of the entire forest area is necessary. Hence the following is offered:

TABLE 13.—*Classification of forest land.*

Region.	Total forest and woodland area.	Probably mature timber and woods.		Probably not restocking.		Probably growing forest and woodland.	
	Acres.	*Per cent.*	*Acres.*	*Per cent.*	*Acres.*	*Per cent.*	*Acres.*
Lake States	47,000,000	4	2,000,000	38	18,000,000	58	27,000,000
Northeastern States	48,000,000	4	2,000,000	18	8,000,000	78	38,000,000
Central States	71,000,000	9	6,000,000	15	11,000,000	76	54,000,000
Southern States:							
Pine land (60 per cent)	124,000,000	33	41,000,000	27	33,000,000	40	50,000,000
Hard wood land (40 per cent)	82,000,000	43	35,000,000	7	6,000,000	50	41,000,000
Rocky Mountain States	97,000,000	70	68,000,000	12	12,000,000	18	17,000,000
Pacific Coast States	76,000,000	80	61,000,000	3	2,000.000	17	13,000,000
Total	545,000,000	.....	215,000,000	.....	90,000,000	.....	240,000,000

The Lake States include Minnesota, Wisconsin, and Michigan; the Northeastern States include Maine, Vermont, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, and Pennsylvania; the Central States include West Virginia, Ohio,

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Indiana, Illinois, Kentucky, Tennessee, Iowa, North Dakota, South Dakota, Nebraska, Kansas, and Missouri; the Southern States include Maryland, Delaware, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, Texas, and Oklahoma; the Rocky Mountain States include Montana, Idaho, Utah, Wyoming, Colorado, Nevada, Arizona, and New Mexico; the Pacific Coast States include Washington, Oregon, and California.

The total forest area, including woodland, is seen to amount to approximately 545,000,000 acres, of which about 50,000,000 acres are scrubby woodland, producing only cord wood. This is confined largely to the Southwest, such as the scrub oak, piñon, and juniper lands of California, New Mexico, Arizona, Texas, and other Rocky Mountain States. This estimate of total forest area is based on almost complete returns from county clerks, usually supporting estimates previously made by the United States Geological Survey for Washington and Oregon, the Forest Service forest maps of California and New Hampshire, and the more general state estimates of Doctor Fernow.

The classification into mature timber and cut and burned land probably not restocking are estimates based on reports of Professor Roth for Michigan and Wisconsin and General Andrews for Minnesota, the Geological Survey revised township estimate for Washington and Oregon, by Henry Gannett, together with special reports of state foresters, and more general regional reports, such as the "Report of the Secretary of Agriculture on the White Mountains and Southern Appalachian Watersheds, 1908;" "Southern Appalachian Forests," Ayers and Ashe, Geological Survey; "Timber Pines of the Southern United States," Forest Service Bulletin 13, by Roth, etc. That some difference of opinion may be expressed on this classification is not to be doubted, but the totals are good, errors in high and low estimates compensating to some degree.

The mature timber totals over 188,000,000 acres, which might be raised to approximately 215,000,000 if all woodland such as the scub oak, juniper, and piñon lands of the Southwest is included. It is evident that there is little mature timber in the Lake and Northeastern States. The States included as Central States have a little more mature timber, though culled forests, which consist largely of mature trees, are here included under growing forests to be conservative. The Southern States are figured as having one-third mature timber on pine lands and a little larger proportion of the hard woods of the alluvial bottoms and southern Appalachians. The Rocky Mountain and Pacific coast forests are largely mature forests. Since there has been a great lumber output on the coast it might be supposed that the Rocky Mountain region should have a larger percentage of mature forest, but the thinner forest of the Rockies and much greater damage from fire have tended to lessen the mature forest percentage and greatly increase the "not restocking" percentage. This large area of mature forest can not be considered as increasing materially by growth above the loss by decay, windfalls, insects, etc. The burned areas restocking are included under growing forest.

Under the head of "Probably not restocking" the Lake States lead with 38 per cent. This is due perhaps to the more complete re-

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ports and forest and logging conditions which invited the many great conflagrations credited to this region. The larger amount of hard wood, different topography, denser population, larger percentage in small wood lots, and other factors decrease the percentage of forest not restocking for the Northeastern States. These same factors—notably the composition of the forest as of hard woods almost entirely with sprout reproduction—lessen it still more for the Central States. In the Southern States on the pine lands it rises sharply and would be still higher were not the effects of fires less destructive in the more open mature forests still existing. Southern hard woods suffer much less. This is due to their location in the lowlands and mountains, to the less inflammability of nonresinous wood, and to sprout reproduction. In proportion to the cut-over land the Rocky Mountains show a large percentage of land not restocking, while the Pacific coast climatic conditions make reseeding better and safer. The areas of land not restocking are believed to be very conservative even though the total seems startling when placed at about 82,000,000 acres of forest land or 90,000,000 acres of forest and woodland. To the observant forester several trips through the Lake State pineries and southern pineries (where one-half of this land is to be found) are sufficiently convincing. This is the second large item which must be withdrawn from the total so-called forest area. The question may be raised whether this has not already been excluded in the classification of total forest and woodland. It is not, because it is inseparably mingled with the mature and growing timber areas, and it is still potential forest land but unable to restock on account of recurring fires and lack of seed trees. For example, Minnesota is given 15,000,000 acres of forest land, only 7,500,000 of which is restocking to a degree indicative of a second crop. The other 7,500,000, while not entirely devoid of tree growth, will require many decades of efficient fire protection and a large amount of artificial regeneration to bring it into the producing forest class.

The growing forest area is gotten by deducting the mature forest and the area not restocking from the total forest area. This is approximately 225,000,000 acres of forest land, or 240,000,000 acres of forest and woodland. These figures give a total forest area of about 495,000,000 acres, which is raised to 545,000,000 to include woodlands (lands incapable of producing saw timber forest).

Having thus analyzed the total forest area and secured an approximation for the area of growing or producing forest, there remains a discussion of the actual increment on this area. Since (as has been stated before) the growing forest is made up of all conditions of growth from the lightly culled mature forests producing little increment to the pure dense stands of young growth with an increment approaching the maximum, the arriving at an average production is very difficult. The most important single factor is the amount of growing stock present or the density. The second is the age of the growing stock.

In the first column of the table below, the annual production per acre of fully stocked forest is taken as the basis for calculation (being the average for the life of the trees to maturity for all qualities of forest). This is expressed in cubic feet of stem volume (not all of which is merchantable) gotten from the few American yield tables

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(see Appendix) supplemented by German yield tables, and weighted roughly according to the species in the growing forests of each region.

TABLE 14.—*Estimated growth per acre.*

Region.	Average estimated production in fully stocked forest per acre per year.	Average "best virgin forest" density in per cent of fully stocked.	Estimated density of immature forest compared with best virgin.	Probable growth per acre in growing forest.
	Cubic feet.	*Per cent.*	*Per cent.*	*Cubic feet.*
Lake States	90	60	70	38
Northeastern States	80	60	70	33
Central States	60	70	60	25
Southern States:				
Pine land	70	46	65	21
Hard-wood land	70	70	60	29
Rocky Mountain States	30	53	60	9
Pacific coast States	110	73	70	56

In order to see how the density of our virgin forests compares with the fully stocked forests of the yield tables recourse is taken to a comparison of basal areas (area of tree cross sections). The total basal area (see Appendix) for northern virgin forests containing a large percentage of conifers ranges from 75 to 200 square feet, averaging about 120; the central hard-wood forests from 90 to 150, averaging about 117 square feet; the southern pine forests 30 to 120, averaging 70 square feet; the Rocky Mountain forests 30 to 130, averaging 80 square feet; and the Pacific coast forests 190 to 240, averaging 220 square feet. These basal areas, when compared with Quality II 80-year white pine in New England (see Appendix for normal yield table basal areas and increments), with 242 square feet per acre; paper birch, Quality I, 60 years, in New England, with 120 square feet; loblolly pine in Texas, at 40 years, with 126 square feet; second-growth hard woods in the Southern Appalachians, with 140 square feet; Norway spruce 120 years old, in Germany, with 288 square feet; beech with 192 square feet; and Scotch pine with 212 square feet, show that our virgin forests, even of the best grades as selected and of much greater age than the normal forests compared, are not nearly normally stocked—the redwoods of California being exceptional. This deficiency of stocking in the best virgin forest is expressed by a percentage in column 2 of the above table. Column 3 gives the estimated relation between the immature or growing forest and the best virgin tracts. Here the percentage for the central and southern hard woods is placed at 60, in order to allow for the large number of mature trees still in these culled forests. The density, including these mature nonproducing trees, would of course be much higher than 60 per cent of the virgin forest density.

By multiplying the production in the fully stocked forest (Table 14) by the percentages of effective stocking in virgin and growing forests successively, the last column of that table is secured, indicating a production of from 21 to 56 cubic feet per acre per year in the immature forest in all regions except the Rocky Mountain region, where the large area of juniper, piñon, and scrub oak woodland included in the total wooded area reduces an already low average

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growth to approximately 9 cubic feet. These figures are believed to be, if anything, higher than the truth.

Applying this estimated average growth to the area of growing forest—

TABLE 15.

Region.	Probable area of growing forest and woodland.	Estimated growth per acre.	Estimated total production.
	Acres.	*Cubic feet.*	*Cubic feet.*
Lake States	27,000,000	38	1,026,000,000
Northeastern States	38,000,000	33	1,254,000,000
Central States	54,000,000	25	1,350,000,000
Southern States:			
Pine land	50,000,000	21	1,050,000,000
Hard-wood land	41,000,000	29	1,189,000,000
Rocky Mountain States	17,000,000	9	153,000,000
Pacific coast States	13,000,000	56	728,000,000
Total	240,000,000	[a]28	6,750,000,000

[a] Average.

an estimated total production of about 6,700,000,000 cubic feet is indicated. This is an average of about 28 cubic feet per acre for the estimated 240,000,000 acres of growing forest and woodland, or about 12 cubic feet for the entire forest and woodland area of 545,000,000 acres, including mature and devastated forests.

Of this probable total of 6,700,000,000 cubic feet the part suitable for saw timber would represent an actual mill output of probably much less than 20,000,000,000 board feet, the rest being cord wood and mill waste.

APPENDIX.

Arbor vitæ.

Age.	Diameter growth.		Height growth.	
	St. Louis County, Minn.[a]			
	Diameter breast-high	Basis.	Height.	Basis.
	Inches.		*Feet.*	
10 years	0.3	Decade measurements on 44 1-foot stumps 70 to 150 years old.	6	Age diameter and diameter-height curves.
20 years	0.7		8	
30 years	1.2		11	
40 years	1.6		13	
50 years	2.1		15	
60 years	2.8		18	
70 years	3.5		22	
80 years	4.2		25	
90 years	5.3		29	
100 years	6.2		32	
110 years	7.0		34	
120 years	7.5		36	
130 years	8.0		38	
140 years	8.3		39	
150 years	8.8		40	
160 years	9.4		40	
170 years	10.1			

[a] White Pine Study, by C. S. Chapman, 1903.

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Ash, green.

Age.	Diameter growth.		Height growth.	
	Eastern Nebraska.[a]			
	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Feet.*	
10 years	2.1	5-year measurements on 57 5-foot stumps 14 to 44 years old.	19	7-foot section measurements on 57 trees 14 to 44 years old.
20 years	3.6		28	
30 years	5.0		36	
40 years	5.4		40	
50 years	5.6		43	

[a] Plantations, L. C. Miller, 1904.

Ash, white.

Age.	Diameter growth.	
	Dutchess County, N. Y.[a]	
	Diameter breast-high.	Basis.
	Inches.	
10 years	1.6	5-year measurements on 15 4.5-foot stumps 7 to 44 years old.
20 years	3.2	
30 years	4.2	
40 years	4.8	

[a] Rogers and Huyler Working Plan, by J. G. Peters, 1905.

Ash, white and green.

Age.	Diameter growth.			
	Richland County, S. C.[a]		Mississippi County, Ark.[b]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	
10 years	2.7	Decade measurements on 410 2-foot stumps 32 to 180 years old.	2.6	Decade measurements on 331 3-foot stumps 39 to 162 years old.
20 years	5.2		5.4	
30 years	7.3		7.8	
40 years	9.3		10.0	
50 years	11.2		12.1	
60 years	13.1		14.0	
70 years	14.8		15.8	
80 years	16.6		17.5	
90 years	18.3		19.0	
100 years	19.8		20.3	
110 years	21.5		.....	
120 years	23.0		.....	
130 years	24.6		.....	
140 years	26.1		.....	
150 years	27.7		.....	

[a] Ash Study, by K. W. Woodward, 1905.

[b] Ash Study, by G. M. Homans, 1905.

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Aspen.

Age.	Diameter growth.				Height growth.	
	(With jack pine) Hubbard County, Minn.[a]		Franklin and Somerset counties, Me.[b]		Franklin and Somerset counties, Me.	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Inches.*		*Feet.*	
10 years	1.1	Breast-high decade measurements on 6 trees 39 to 84 years old.	1.5	5-year measurements on 409 4.5-foot stumps 5 to 89 years old.	15	2639 sectional ring counts.
20 years	2.7		3.7		32	
30 years	4.0		6.0		45	
40 years	5.4		7.9		56	
50 years	6.8		9.4		65	
60 years	.....		10.6		71	
70 years	.....		11.5		74	
80 years	.....		12.0		75	
90 years	.....		12.5		77	
100 years	.....		12.8		78	
110 years	.....		.....		79	
120 years	.....		.....		80	

[a] Red Pine Study, by H. H. Chapman, 1905. [b] Aspen Study, by R. L. Marston, 1903.

Basswood.

Age.	Diameter growth.	
	Leelanau County, Mich.[a]	
	Diameter breast-high.	Basis.
	Inches.	
10 years	1.4	Decade measurements on 78 2.1 to 3.0 foot stumps 68 to 180 years old.
20 years	2.9	
30 years	4.5	
40 years	6.3	
50 years	8.1	
60 years	9.9	
70 years	11.6	
80 years	13.2	
90 years	14.5	
100 years	15.7	
110 years	16.6	
120 years	17.5	
130 years	18.1	
140 years	18.6	
150 years	19.1	
160 years	19.4	
170 years	19.8	
180 years	20.0	
190 years	20.2	
200 years	20.4	

[a] Newhall Working Plan, by S. J. Record, 1905.

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Beech.

Age.	Diameter growth.			
	Leelanau County, Mich.[a]		Franklin County, N.Y.[b]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	
10 years	0.2		0.6	
20 years	1.0		1.0	
30 years	1.8		1.5	
40 years	2.7		2.0	
50 years	3.8		2.5	
60 years	5.3		3.2	
70 years	6.7		3.8	
80 years	8.0		4.6	
90 years	9.2		5.5	
100 years	10.2		6.4	
110 years	11.0	Decade measurements at 2.0 to 2.9 feet on 61 trees 69 to 202 years old.	7.4	189 trees with stumps of various heights and diameters.
120 years	11.7		8.5	
130 years	12.3		9.5	
140 years	13.0		10.6	
150 years	13.6		11.6	
160 years	14.3		12.6	
170 years	14.8		13.6	
180 years	15.4		14.6	
190 years	16.0		15.6	
200 years	16.6		16.5	
210 years	.....		17.5	
220 years	.....		18.5	
230 years	.....		19.5	
240 years	.....		20.5	
250 years	.....		21.5	
260 years	.....		22.5	
270 years	.....		23.4	
280 years	.....		24.3	
290 years	.....		25.0	
300 years	.....		25.7	

[a] Newhall Working Plan, by S. J. Record, 1905.
[b] Working Plan for St. Regis Tract, by O. W. Price, 1899.

Birch, paper.

Age.	Diameter growth.				Height growth.			
	Seedling.[a]		Sprout.[b]		Seedling.		Sprout.	
	Piscataquis County, Me.[c]		Carroll County, N. H.[c]		Piscataquis County, Me.[c]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.	Height.	Basis.
	Inches.		*Inches.*		*Feet.*		*Feet.*	
10 years	1.1	Decade measurements on 50 1 to 2 foot stumps 62 to 88 years old.	1.8	Decade measurements on 30 1 to 2 foot stumps 43 to 61 years old.	13	Sectional age counts on 50 trees.	19	Sectional age counts on 30 trees.
20 years	3.4		4.0		30		36	
30 years	5.3		6.9		44		49	
40 years	6.8		7.9		54		60	
50 years	8.0		8.8		62		70	
60 years	8.9		.....		68		78	
70 years	9.7		.....		74		.....	
80 years	10.2		.....		78		.....	
90 years	.....		.....		81		.....	

[a] Low, rocky ground near a pond.
[b] Very rocky thin-soiled hillside.
[c] Paper Birch Study, by S. T. Dana, 1907.

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Birch, yellow.

Age.	Diameter growth.			
	Leelanau County, Mich.[a]		Franklin County, N. Y.[b]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	
10 years	0.9	Decade measurements on 20 2 to 2.9 foot stumps 75 to 187 years old.	1.1	332 trees with stumps of various heights and diameters.
20 years	2.3		1.8	
30 years	3.8		2.6	
40 years	5.3		3.5	
50 years	6.8		4.5	
60 years	8.4		5.4	
70 years	10.0		6.4	
80 years	11.5		7.4	
90 years	12.9		8.4	
100 years	14.2		9.4	
110 years	15.4		10.4	
120 years	16.6		11.4	
130 years	17.7		12.4	
140 years	18.9		13.4	
150 years	20.0		14.4	
160 years	21.1		15.5	
170 years	22.2		16.5	
180 years	23.3		17.5	
190 years	24.4		18.5	
200 years	25.5		19.4	
210 years	.....		20.2	
220 years	.....		21.1	
230 years	.....		21.9	
240 years	.....		22.7	
250 years	.....		23.4	
260 years	.....		24.1	
270 years	.....		24.7	
280 years	.....		25.3	
290 years	.....		25.9	
300 years	.....		26.4	

[a] Newhall Working Plan, by S. J. Record, 1905.
[b] Working Plan for St. Regis Tract, by O. W. Price, 1899.

Catalpa.

Age.	Diameter growth.		Height growth.	
	Eastern Nebraska.[a]			
	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Feet.*	
10 years	2.8	5-year measurements on 24 5-foot stumps 15 to 25 years old.	19	7-foot sections on 24 trees 15 to 25 years old.
20 years	4.9		27	
30 years	6.4		33	

[a] Plantations, L. C. Miller, 1904.

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Cedar, red.

Age.	Diameter growth.							
	Open grown.		Forest grown.[a]					
	Marengo and Perry counties, Ala.[b c]						Dutchess County, N. Y.[d e]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	1.0	Decade measurements on 46 0.5 to 1 foot stumps 51 to 95 years old.	0.4	Decade measurements on 296 0.5 to 1 foot stumps 56 to 92 years old.	0.2	Decade measurements on 68 0.5 to 1 foot stumps 68 to 84 years old.	0.7	5-year measurements on 28 0.5-foot stumps 34 to 67 years old.
20 years	3.9		2.7		1.3		1.9	
30 years	6.9		5.0		2.7		2.8	
40 years	9.3		7.1		4.4		3.6	
50 years	11.2		9.0		6.5		4.2	
60 years	12.8		10.7		8.9		4.8	
70 years	14.3		12.3		11.4		.....	
80 years	15.6		14.0		13.9		.....	
90 years	.....		15.7		.....		.....	

Age.	Height growth.			
	Forest grown.		Open grown.	
	Marengo and Perry counties, Ala.[b c]			
	Height.	Basis.	Height.	Basis.
	Feet.		*Feet.*	
10 years	4.3	Section measurements on 161 trees.	6.6	Section measurements on 60 trees.
20 years	13.0		19.6	
30 years	23.2		21.1	
40 years	33.4		.....	
50 years	.....		.....	
60 years	.....		.....	
70 years	.....		.....	
80 years	.....		.....	
90 years	.....		.....	

[a] Suppressed for about twenty years.
[b] About 50 per cent cedar; rest hard woods. Moderately deep soil. Situation varies from coves to flat uplands.
[c] Red Cedar Study, by L. L. White, 1906.
[d] Rogers and Huyler Working Plan, by J. G. Peters, 1905.
[e] Old field type. Agricultural soil.

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Chestnut.

Age.	Diameter growth. Slope. Dutchess County, N. Y.[a] [b] Diameter breast-high.	Basis.	Nicholas County, W. Va.[c] Diameter breast-high.	Basis.	Johnson County, Tenn.[c] Diameter breast-high.	Basis.	Polk and Monroe counties, Tenn.[c] Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	2.5	Decade measurements on 33 1.5-foot stumps 29 to 70 years old.	0.5	Decade measurements on 60 2.5-foot stumps 54 to 200 years old.	0.4	Decade measurements on 52 2.5-foot stumps 56 to 194 years old.	0.5	Decade measurements on 67 2.5-foot stumps 24 to 200 years old.
20 years	4.9		2.4		2.5		3.0	
30 years	7.2		4.3		4.8		5.3	
40 years	9.4		6.4		7.2		7.3	
50 years	11.4		8.4		9.4		9.4	
60 years	12.9		10.4		11.4		11.4	
70 years	.....		12.5		13.1		13.4	
80 years	.....		14.4		14.5		15.3	
90 years	.....		16.3		?15.7		17.2	
100 years	.....		18.2		?16.9		18.9	
110 years	.....		19.9		?17.8		20.3	
120 years	.....		21.6		?18.7		21.6	
130 years	.....		23.2		?19.6		22.8	
140 years	.....		24.9		?20.4		23.9	
150 years	.....		26.6		?21.2		24.7	
160 years	.....		28.4		?22.0		25.5	
170 years	.....		30.2		?22.7		26.3	
180 years	.....		31.9		?23.4		27.0	
190 years	.....		33.3		?24.2		27.7	
200 years	.....		.....		?24.9		28.4	

Age.	Diameter growth. Cove. Polk and Monroe counties, Tenn.[c] Diameter breast-high.	Basis.	Second growth. Lyon County, W. Va.[d] Diameter breast-high.	Basis.	Seedlings. Prince George, Charles, Calvert, and Anne Arundel counties, Md.[e] [f] Diameter breast-high.	Basis.	Coppice. Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	0.7	Decade measurements on 66 0.5 to 4.5 foot stumps 21 to 176 years old.	1.6	Decade measurements on 47 4.5-foot stumps 14 to 65 years old.	0.8	499 trees.	3.8	3,823 trees.
20 years	3.1		3.7		3.4		6.8	
30 years	5.6		5.4		6.0		9.3	
40 years	8.2		6.9		8.7		11.4	
50 years	11.1		8.3		11.2		13.4	
60 years	13.7		9.6		13.4		15.1	
70 years	16.0		11.0		15.4		16.7	
80 years	18.4		.....		17.2		18.0	
90 years	20.3		.....		18.8		19.2	
100 years	21.7		.....		20.1		19.8	
110 years	?22.7		.....		21.0		20.4	
120 years	?23.5		.....		21.6		20.8	
130 years	?24.1		.....		.....		.....	
140 years	?24.5		.....		.....		.....	
150 years	?24.9		.....		.....		.....	
160 years	?25.1		.....		.....		.....	
170 years	?25.3		.....		.....		.....	
180 years	?25.5		.....		.....		.....	
190 years	.....		.....		.....		.....	
200 years	.....		.....		.....		.....	

[a] Rogers and Huyler Working Plan, by J. G. Peters, 1905.
[b] On white oak type.
[c] Commercial Tree Study, Walter Mulford, 1905–6.
[d] United States Coal and Oil Lands, R. C. Hawley, 1904.
[e] Chestnut Study, by R. Zon, 1902.
[f] In mixture with scrub pine and hard woods on gentle slopes.

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Chestnut—Continued.

Age.	Height growth.			
	Seedlings.		Coppice.	
	Prince George, Charles, Calvert, and Anne Arundel counties, Md. [a] [b]			
	Height.	Basis.	Height.	Basis.
	Feet.		*Feet.*	
10 years	7		23	
20 years	17		42	
30 years	33		57	
40 years	52		69	
50 years	64		77	
60 years	73		83	
70 years	80		87	
80 years	84		90	
90 years	88	181 trees.	92	1,071 trees.
100 years	91		93	
110 years	93		94	
120 years	95		95	
130 years				
140 years				
150 years				
160 years				
170 years				
180 years				
190 years				
200 years				

[a] Chestnut Study, by R. Zon, 1902.
[b] In mixture with scrub pine and hard woods on gentle slopes.

Cottonwood.

Age.	Diameter growth.						Height growth.	
	Bolivar County, Miss.[a]		Richland County, S. C.[a]		Eastern Nebraska.[b]		Eastern Nebraska.[b]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Inches.*		*Inches.*		*Feet.*	
10 years	8.1		6.2		5.1		33	
20 years	15.8	Decade measurements on 335 3-foot stumps 12 to 166 years old.	12.6	Decade measurements on 396 3-foot stumps 14 to 131 years old.	9.4	4-year measurements on 50 1-foot stumps 9 to 46 years old.	55	7-foot sections on 50 trees 9 to 46 years old.
30 years	21.7		17.4		12.2		65	
40 years	26.6		21.4		13.3		69	
50 years	30.4		25.1		13.8		73	
60 years	33.4		28.2					
70 years	36.0		30.9					
80 years	38.4		33.5					
90 years	40.8		35.7					
100 years			37.6					
110 years			39.3					
120 years			40.7					

[a] Cottonwood Study, by G. M. Homans and K. W. Woodward, 1905.
[b] Plantations, L. C. Miller, 1904.

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Fir, alpine.

Age.	Height growth. Gunnison County, Colo.[a]	Age.	Height growth. Gunnison County, Colo.[a]
	Feet.		*Feet.*
10 years	2.0	50 years	6.7
20 years	3.7	60 years	7.3
30 years	5.1	70 years	7.8
40 years	6.1		

[a] Planting Reconnaissance, S. B. Detweiler, 1905.

Fir, balsam.

Age.	Diameter growth. Hardwood slope. Franklin County, N. Y.[a] Diameter breast-high.	Basis.	Diameter growth. Dry swamp. Franklin County, N. Y.[a] Diameter breast-high.	Basis.	Diameter growth. Wet swamp. Franklin County, N. Y.[a] Diameter breast-high.	Basis.	Diameter growth. Somerset County, Me.[a] Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	0.2		0.2		.....		.....	
20 years	1.2		1.2		0.7		1.1	
30 years	2.5		2.3		1.7		2.0	
40 years	4.0	Decade measurements on 613 trees with varying stumps 17 to 147 years old.	3.7	Decade measurements on 448 trees with varying stumps 25 to 149 years old.	2.7	Decade measurements on 372 trees with varying stumps 18 to 150 years old.	2.9	Decade measurements on 135 4.5-foot stumps 18 to 109 years old.
50 years	5.2		5.2		3.9		3.7	
60 years	6.2		6.2		4.9		4.4	
70 years	7.0		6.9		5.7		5.0	
80 years	7.5		7.2		6.2		5.4	
90 years	8.0		7.5		6.6		5.8	
100 years	8.4		7.6		7.0		6.0	
110 years	8.7		7.8		7.3		6.2	
120 years	9.0		7.9		7.5		6.6	
130 years	9.3		8.1		7.7		.....	
140 years	9.6		8.2		7.9		.....	
150 years	9.8		8.3		8.0		.....	

Age.	Diameter growth. St. Louis County, Minn.[b] Diameter breast-high.	Basis.	Height growth. St. Louis County, Minn.[b] Height.	Basis.
	Inches.		*Feet.*	
10 years	.....		2.5	
20 years	.....		4.4	
30 years	1.0		5.0	
40 years	2.2		5.6	
50 years	3.5	Decade measurements on 68 4.5-foot stumps 41 to 128 years old.	6.6	298 trees.
60 years	4.7		.....	
70 years	5.8		.....	
80 years	6.9		.....	
90 years	8.0		.....	
100 years	8.8		.....	
110 years	9.4		.....	
120 years	9.8		.....	
130 years	10.1		.....	
140 years	.....		.....	
150 years	.....		.....	

[a] Balsam Fir Study, by R. Zon, 1903–4.
[b] White Pine Study, by C. S. Chapman, 1903.

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Fir, white.

Age.	Diameter growth.							
	Bottom.		Plateau.		Slope.		All types.	
	Siskiyou County, Cal.[a]							
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	.....	Decade measurements on 279 4.5-foot stumps 27 to 200 years old.	.....	Decade measurements on 214 4.5-foot stumps 42 to 198 years old.	.....	Decade measurements on 393 4.5-foot stumps 45 to 200 years old.	.....	Decade measurements on 876 4.5-foot stumps 30 to 285 years old.
20 years	.....		.....		.....		.....	
30 years	1.2		.....		.....		0.7	
40 years	2.4		1.7		1.6		2.3	
50 years	3.6		3.3		3.1		3.9	
60 years	5.0		5.1		4.8		5.7	
70 years	6.4		7.3		6.5		7.4	
80 years	7.9		9.7		8.1		9.0	
90 years	9.3		12.3		9.5		10.7	
100 years	11.0		14.7		10.7		12.2	
110 years	12.4		17.3		11.9		13.6	
120 years	13.8		19.9		12.9		15.2	
130 years	15.0		22.3		13.9		16.7	
140 years	16.2		24.7		14.9		18.1	
150 years	17.3		26.8		15.9		19.5	
160 years	18.3		28.6		16.9		20.9	
170 years	19.3		30.2		17.9		22.2	
180 years	20.3		31.6		18.8		23.5	
190 years	21.3		.....		19.8		24.8	
200 years	22.2		.....		20.7		26.0	

Age.	Height growth.							
	Bottom.		Slope.		Plateau.		All types.	
	Siskiyou County, Cal.[a]							
	Height.	Basis.	Height.	Basis.	Height.	Basis.	Height.	Basis.
	Feet.		*Feet.*		*Feet.*		*Feet.*	
10 years	.....	Combined age and height curves.	.....	Combined age and height curves.	.....	Combined age and height curves.	.....	Combined growth diameter and height curves.
20 years	.....		.....		.....		.....	
30 years	10		.....		.....		8	
40 years	16		13		12		16	
50 years	23		22		20		24	
60 years	30		33		30		36	
70 years	38		44		44		46	
80 years	47		55		56		57	
90 years	56		63		69		67	
100 years	67		71		79		76	
110 years	75		78		90		83	
120 years	83		83		101		91	
130 years	90		88		112		99	
140 years	96		93		122		105	
150 years	104		97		131		111	
160 years	107		101		138		117	
170 years	112		106		143		122	
180 years	117		110		147		127	
190 years	121		114		.....		132	
200 years	125		118		.....	.....	136	

[a] White Fir Study, by P. D. Kelleter, 1905.

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Gum, red.

Age.	Diameter growth.			
	New Madrid County, Mo.[a]		Richland County, S. C.[a]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	
10 years	1.6	Decade measurements on 656 stumps of various heights and diameters.	3.8	Decade measurements on 796 stumps of various heights and diameters.
20 years	3.8		7.8	
30 years	6.3		11.2	
40 years	9.2		14.2	
50 years	12.2		16.8	
60 years	15.1		19.2	
70 years	18.0		21.4	
80 years	20.9		23.4	
90 years	23.5		25.3	
100 years	25.8		26.9	
110 years	27.7		28.4	
120 years	29.3		29.9	
130 years	30.7		31.3	
140 years	31.8		32.7	
150 years	32.8		34.2	
160 years	33.6		35.6	
170 years	34.3		37.1	
180 years	34.9		38.6	
190 years	35.4		40.0	
200 years	35.9		.....	
210 years	36.3		.....	
220 years	36.6		.....	
230 years	37.0		.....	
240 years	37.3		.....	
250 years	37.6		.....	
260 years	37.8		.....	
270 years	38.1		.....	
280 years	38.4		.....	
290 years	38.6		.....	
300 years	38.9		.....	

[a] Red Gum Study, by A. K. Chittenden, 1903–4.

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Hemlock.

Age.	Diameter growth.					
	Johnson County, Tenn.[a]		Mitchell County, N. C.[a]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*	
20 years	0.2		0.3			
30 years	.9		1.0		1.1	
40 years	1.9		1.8		2.2	
50 years	3.0		2.8		3.4	
60 years	4.1		3.8		4.7	
70 years	5.3		4.9		6.2	
80 years	6.7		6.2		7.6	
90 years	8.0		7.3		9.1	
100 years	9.4		8.6		10.5	
110 years	10.7		9.7		11.9	
120 years	11.8	Decade measurements on 131 2.5-foot stumps 111 to 200 years old.	11.0	Decade measurements on 124 2-foot stumps 100 to 200 years old.	13.2	Decade measurements on 308 3-foot stumps 89 to 200 years old.
130 years	12.9		12.2		14.5	
140 years	14.0		13.5		15.5	
150 years	15.1		14.6		16.5	
160 years	16.1		15.7		17.4	
170 years	17.1		16.5		18.3	
180 years	18.1		17.4		19.2	
190 years	19.1		18.2		20.0	
200 years	20.0		19.0		20.7	
210 years						
220 years						
230 years						
240 years						
250 years						
260 years						
270 years						
280 years						
290 years						
300 years						

Age.	Diameter growth.			
	Greenbrier County, W. Va.[a]		Leelanau County, Mich.[b]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	
10 years			0.1	
20 years	0.4		.7	
30 years	0.9		1.3	
40 years	1.3		2.1	
50 years	1.9		2.9	
60 years	2.4		3.8	
70 years	2.9		4.7	
80 years	3.6		5.7	
90 years	4.2		6.7	
100 years	4.9		7.8	
110 years	5.6	Decade measurements on 47 2.5-foot stumps 137 to 200 years old.	9.0	Decade measurements on 186 2 to 2.9 foot stumps 109 to 325 years old.
120 years	6.4		10.0	
130 years	7.3		11.2	
140 years	8.1		12.3	
150 years	8.9		13.4	
160 years	9.9		14.5	
170 years	10.9		15.5	
180 years	11.9		16.5	
190 years	12.7		17.5	
200 years	13.5		18.4	
210 years			19.3	
220 years			20.1	
230 years			20.9	
240 years			21.6	
250 years			22.2	
260 years			22.8	
270 years			23.3	
280 years			23.8	
290 years			24.3	
300 years			24.7	

[a] Commercial Tree Study, by Walter Mulford, 1905–6.
[b] Newhall Working Plan, by S. J. Record, 1905.

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Hickories.

Age	Diameter growth. Dutchess County, N. Y.[a] Diameter breast-high.	Basis.
	Inches.	
10 years	1.7	5-year measurements on 12 4.5-foot stumps 28 to 62 years old.
20 years	3.6	
30 years	5.4	
40 years	7.1	
50 years	8.6	
60 years	10.0	

Age.	Diameter growth. Ohio Valley.[b] Diameter breast-high. Mockernut.	Pignut.	Shagbark.	Age.	Diameter growth. Ohio Valley.[b] Diameter breast-high. Mockernut.	Pignut.	Shagbark.
	Inches.	*Inches.*	*Inches.*		*Inches.*	*Inches.*	*Inches.*
10 years	0.9	0.6	0.6	70 years	10.9	8.6	7.8
20 years	2.6	1.8	1.7	80 years	12.5	10.0	9.0
30 years	4.3	3.1	2.9	90 years	14.1	11.4	10.3
40 years	6.0	4.4	4.1	100 years	15.7	12.9	11.6
50 years	7.7	5.7	5.3	110 years	17.3	13.3	12.9
60 years	9.3	7.2	6.5	120 years	18.9	15.7	14.2

[a] Rogers and Huyler Working Plan, by J. G. Peters, 1905.
[b] Hickory Study, A. T. Boisen, 1907.

Juniper, Rocky Mountain.

Age.	Diameter growth. Partially shaded. Randall County, Tex.[a] Diameter breast-high.	Basis.	Diameter growth. Open grown. Diameter breast-high.	Basis.	Height growth. Partially shaded. Height.	Open grown. Height.
	Inches.		*Inches.*		*Feet.*	*Feet.*
10 years		Stumps 1 foot high.		Stumps 1 foot high.		
20 years						
30 years						
40 years						
50 years						
60 years	5.5		8.5		31	34
70 years	6.4		9.8		33	36
80 years	7.2		11.1		35	39
90 years	8.0		12.1		37	41
100 years	8.8		12.9		38	43
110 years	9.5		13.6		40	45
120 years	10.1		14.2		41	47
130 years	10.7		14.6		42	49
140 years	11.2		15.0		43	50
150 years	11.7				44	
160 years	12.2				45	
170 years	12.7				47	
180 years	13.2				49	
190 years	13.7				50	
200 years	14.2				52	

[a] Palodura Tract, H. H. Chapman, 1904.

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Locust, honey.

Age.	Diameter growth.		Height growth.	
	Eastern Nebraska.[a]			
	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Feet.*	
10 years	3.6	5-year measurements on 5-foot stumps 17 to 35 years old.	18	7-foot sections on 12 trees 17 to 35 years old.
20 years	5.3		27	
30 years	6.7		35	
40 years	.....		43	

[a] Plantations, L. C. Miller, 1904.

Locust, black.

Age.	Diameter growth.					
	Close stand.		Broken stand.		Open stand.	
	Northeastern Kentucky.[a]					
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*	
10 years	2.7	15 stumps 20 to 42 years old.	3.8	24 stumps 9 to 38 years old.	5.0	15 stumps 10 to 28 years old.
20 years	5.2		6.8		9.3	
30 years	7.1		9.0		.....	
40 years	8.7		10.7		.....	

[a] Forest conditions in Kentucky, J. S. Holmes, 1908.

Maple, red.

Age.	Diameter growth.	
	Dutchess County, N. Y.[a]	
	Diameter breast-high.	Basis.
	Inches.	
10 years	1.6	5-year measurements on 25 4.5-foot stumps 12 to 87 years old.
20 years	3.1	
30 years	4.5	
40 years	5.8	
50 years	7.0	
60 years	8.0	
70 years	8.0	

[a] Rogers and Huyler Working Plan, by J. G. Peters, 1905.

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Maple, silver.

Age.	Diameter growth.		Height growth.	
	Eastern Nebraska.[a]			
	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Feet.*	
10 years	3.1	5-year measurements on 11 1-foot stumps 16 to 34 years old.	22	7-foot sections on 11 trees 16 to 34 years old.
20 years	5.1		44	
30 years	7.5		60	
40 years	9.0		72	
			80	

[a] Plantations, L. C. Miller, 1904.

Maple, sugar.

Age.	Diameter growth.			
	Leelanau County, Mich.[a]		Franklin County, N. Y.[b]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	
10 years	0.2	Decade measurements on 261 2.1 to 3 foot stumps 64 to 214 years old.	0.6	548 trees with stumps of various heights and diameters.
20 years	1.0		1.3	
30 years	1.9		1.9	
40 years	2.8		2.7	
50 years	3.8		3.5	
60 years	4.9		4.3	
70 years	5.9		5.2	
80 years	7.0		6.0	
90 years	8.0		6.9	
100 years	9.0		7.8	
110 years	10.1		8.8	
120 years	11.1		9.8	
130 years	12.1		10.9	
140 years	13.1		11.9	
150 years	14.0		12.9	
160 years	14.8		14.0	
170 years	15.6		15.0	
180 years	16.4		16.0	
190 years	17.1		16.9	
200 years	17.7		17.8	
210 years	.....		18.6	
220 years	.....		19.5	
230 years	.....		20.3	
240 years	.....		21.0	
250 years	.....		21.6	
260 years	.....		22.7	
270 years	.....		23.4	
280 years	.....		24.2	
290 years	.....		25.0	
300 years	.....		25.7	

[a] Newhall Working Plan, by S. J. Record, 1905.
[b] St. Regis Tract, O. W. Price, 1899.

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Oak, black.

Age.	Diameter growth.							
	Slope.		Cove and slope.		Ridge.		Upland and bottom.	
	Polk and Monroe counties, Tenn.[a]		Tennessee.[b]		Tennessee.[b]		Lyon County, Ky.[c]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	.....	Decade measurements on 148 2-foot stumps 40 to 200 years old.	1.4	Decade measurements on 149 2-foot stumps 33 to 124 years old.	1.4	Decade measurements on 166 2-foot stumps 37 to 85 years old.	2.1	Decade measurements of 188 trees with varying stumps 23 to 172 years old.
20 years	1.8		3.8		4.0		4.4	
30 years	3.7		6.6		6.8		6.9	
40 years	5.7		9.3		9.5		9.4	
50 years	7.7		11.5		11.3		11.3	
60 years	9.3		13.0		12.4		12.6	
70 years	10.8		13.9		13.3		13.4	
80 years	12.2		14.7		14.2		13.8	
90 years	13.4		15.3		14.9		14.2	
100 years	14.4		.....		.....		14.4	
110 years	15.5		.....		.....		14.6	
120 years	16.6		.....		.....		.....	
130 years	17.6		.....		.....		.....	
140 years	18.5		.....		.....		.....	
150 years	19.4		.....		.....		.....	
160 years	20.2		.....		.....		.....	
170 years	21.0		.....		.....		.....	
180 years	21.7		.....		.....		.....	
190 years	22.5		.....		.....		.....	
200 years	23.3		.....		.....		.....	

Oak, black and scarlet.

Age.	Diameter growth.						Height growth.	
	Seedling.				Coppice.		Ridge.	
	Laclede County, Mo.[d]		Dutchess County, N. Y.[e] [f]				Tennessee.[b]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Inches.*		*Inches.*		*Feet.*	
10 years	0.6	Decade measurements on 51 4.5-foot stumps 23 to 63 years old.	0.5	5-year measurements on 40 4.5-foot stumps 21 to 68 years old.	1.7	5-year measurements on 77 4.5-foot stumps 11 to 65 years old.	16	944 entries 1 to 85 years old.
20 years	2.6		2.2		3.4		29	
30 years	4.4		3.8		4.9		40	
40 years	6.2		5.3		6.2		51	
50 years	.....		6.7		7.2		61	
60 years	.....		7.7		8.2		70	
70 years	.....		8.5		9.0		77	
80 years	.....		.....		.....		83	
90 years	.....		.....		.....		.....	
100 years	.....		.....		.....		.....	
110 years	.....		.....		.....		.....	
120 years	.....		.....		.....		.....	
130 years	.....		.....		.....		.....	
140 years	.....		.....		.....		.....	
150 years	.....		.....		.....		.....	
160 years	.....		.....		.....		.....	
170 years	.....		.....		.....		.....	
180 years	.....		.....		.....		.....	
190 years	.....		.....		.....		.....	
200 years	.....		.....		.....		.....	

[a] Wetmore and Stevenson Lands. F. E. Olmsted, 1901.
[b] Commercial Tree Study, Walter Mulford, 1905–6.
[c] Hillman Land and Iron Company, A. B. Patterson, 1905.
[d] Forest Conditions in Missouri, S. J. Record, 1906.
[e] Rogers and Huyler Working Plan, J. G. Peters, 1905.
[f] On White Oak Type.

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Oak, chestnut.

Age.[a]	Diameter growth.							
	Coppice.		Cove.		Slope.		Ridge.	
	Dutchess County, N. Y.[a b]		Polk and Monroe counties, Tenn.[c]					
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	2.1	5-year measurements on 53 4.5-foot stumps 12 to 67 years old.	.....	Decade measurements on 26 2 to 3.5 foot stumps 89 to 200 years old.	.....	Decade measurements on 93 1.5 to 4.5 foot stumps 103 to 200 years old.	.....	Decade measurements on 24 1.5 to 4.1 foot stumps 89 to 199 years old.
20 years	3.9		1.7		1.2		0.9	
30 years	5.3		3.7		2.4		1.9	
40 years	6.6		5.6		3.4		2.9	
50 years	7.6		7.3		4.3		4.0	
60 years	8.4		8.9		5.4		5.1	
70 years	9.1		10.3		6.5		6.2	
80 years	.....		11.6		7.7		7.4	
90 years	.....		12.8		8.8		8.6	
100 years	.....		13.9		10.0		9.8	
110 years	.....		15.0		10.9		11.0	
120 years	.....		16.0		12.0		12.2	
130 years	.....		17.0		13.0		13.4	
140 years	.....		18.0		13.9		14.4	
150 years	.....		19.0		14.9		15.3	
160 years	.....		19.8		15.8		16.0	
170 years	.....		20.6		16.7		16.7	
180 years	.....		21.3		17.5		17.2	
190 years	.....		22.1		18.4		17.6	
200 years	.....		22.8		19.3		18.0	

Age.	Diameter growth.				Height growth.			
	Cove, slope, ridge.		Ridge.		Cove and slope.		Ridge.	
	Tennessee.[d]		Jackson County, Ky.[d]		Tennessee.[d]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.	Height.	Basis.
	Inches.		*Inches.*		*Feet.*		*Feet.*	
10 years	1.2	Decade measurements on 44 1.5 to 4.1 foot stumps 4 to 88 years old.	.....	Decade measurements on 161 4.5-foot stumps 78 to 200 years old.	14	120 trees 1 to 86 years old.	14	27 trees 2 to 73 years old.
20 years	3.1		0.7		28		29	
30 years	5.1		1.6		40		40	
40 years	7.1		2.5		49		47	
50 years	8.9		3.4		57		53	
60 years	9.9		4.3		61		58	
70 years	10.4		5.2		63		61	
80 years	10.6		6.1		63		.....	
90 years	10.9		7.0		.....		.....	
100 years	.....		7.9		.....		.....	
110 years	.....		8.9		.....		.....	
120 years	.....		9.9		.....		.....	
130 years	.....		10.8		.....		.....	
140 years	.....		11.9		.....		.....	
150 years	.....		12.9		.....		.....	
160 years	.....		13.9		.....		.....	
170 years	.....		14.8		.....		.....	
180 years	.....		15.7		.....		.....	
190 years	.....		16.5		.....		.....	
200 years	.....		17.4		.....		.....	

[a] Rogers and Huyler Working Plan, by J. G. Peters, 1905.
[b] On Chestnut Oak Type.
[c] Wetmore and Stevenson Lands, F. E. Olmsted, 1901.
[d] Commercial Tree Study, Walter Mulford, 1905-6.

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Oak, red.

Age.	Diameter growth.					
	Slope.		Cove and slope.		Upland and bottom.	
	Swain County, N. C.[a]		Tennessee.[a]		Lyon County, Ky.[b]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*	
10 years	0.2	Decade measurements on 358 3-foot stumps 71 to 200 years old.	1.1	Decade measurements on 32 2.5-foot stumps 47 to 76 years old.	2.2	Decade measurements on 223 trees of varying stumps 20 to 132 years old.
20 years	1.5		3.6		5.0	
30 years	2.8		6.9		7.6	
40 years	4.4		10.3		10.3	
50 years	5.9		12.7		12.4	
60 years	7.5		14.1		14.1	
70 years	9.3		15.0		15.4	
80 years	11.3		15.5		.....	
90 years	13.3		15.8		.....	
100 years	15.3		.....		.....	
110 years	17.1		.....		.....	
120 years	18.7		.....		.....	
130 years	20.3		.....		.....	
140 years	21.6		.....		.....	
150 years	22.7		.....		.....	
160 years	23.8		.....		.....	
170 years	24.8		.....		.....	
180 years	25.8		.....		.....	
190 years	26.8		.....		.....	
200 years	27.6		.....		.....	

Age.	Diameter growth.		Height growth.	
	Coppice.		Cove and slope.	
	Dutchess County, N. Y.[c d]		Tennessee.[a]	
	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Feet.*	
10 years	2.0	Decade measurements on 10 2-foot stumps 62 to 76 years old.	13	99 trees 2 to 76 years old.
20 years	4.1		32	
30 years	6.1		46	
40 years	8.0		60	
50 years	9.8		72	
60 years	11.5		80	
70 years	.....		87	
80 years	.....		.....	
90 years	.....		.....	
100 years	.....		.....	
110 years	.....		.....	
120 years	.....		.....	
130 years	.....		.....	
140 years	.....		.....	
150 years	.....		.....	
160 years	.....		.....	
170 years	.....		.....	
180 years	.....		.....	
190 years	.....		.....	
200 years	.....		.....	

[a] Commercial Tree Study, Walter Mulford, 1905–6.
[b] Hillman Land and Iron Company, A. B. Patterson, 1905.
[c] Rogers and Huyler Working Plan, by J. G. Peters, 1905.
[d] On Chestnut Oak Type.

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Oak, white.

Age.	Diameter growth.							
	Crawford County, Mo.[a]		Second growth.		Seedling.		Coppice.	
			Logan County, W. Va.[b]		Dutchess County, N. Y.[c d]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	.....		1.5		.....		1.9	
20 years	1.1		3.1		2.2		3.9	
30 years	2.2		4.4		4.1		5.4	
40 years	3.2		5.4		5.7		6.6	
50 years	4.2		6.3		7.1		7.6	
60 years	5.2		7.2		8.2		8.4	
70 years	6.2		7.9		9.1		9.1	
80 years	7.2	Decade	8.6	Decade	.....	5-year	.....	5-year
90 years	8.2	measure-	9.3	measure-	.....	measure-	.....	measure-
100 years	9.1	ments	10.0	ments	.....	ments	.....	ments
110 years	10.0	on	.....	on	.....	on	.....	on
120 years	10.9	73	.....	34	.....	29	.....	29
130 years	11.7	2.5-foot	.....	4.5-foot	.....	4.5-foot	.....	4.5-foot
140 years	12.5	stumps	.....	stumps	.....	stumps	.....	stumps
150 years	13.4	113 to 280	.....	17 to 97	.....	15 to 80	.....	8 to 72
160 years	14.2	years	.....	years	.....	years	.....	years
170 years	15.0	old.	.....	old.	.....	old.	.....	old.
180 years	15.8		.....		.....		.....	
190 years	16.6		.....		.....		.....	
200 years	17.5		.....		.....		.....	
210 years	.....		.....		.....		.....	
220 years	.....		.....		.....		.....	
230 years	.....		.....		.....		.....	
240 years	.....		.....		.....		.....	

[a] Forest Conditions in Missouri, S. J. Record, 1906.
[b] United States Coal and Oil Lands, R. C. Hawley, 1904.
[c] Rogers and Huyler Working Plan, J. G. Peters, 1905.
[d] On white oak type.

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Oak, white—Continued.

Age.	Diameter growth.							
	Upland and bottom.		Slope.				Cove.	
	Lyon County, Ky.[a]		Jackson County, Ky.[b]		Polk and Monroe counties, Tenn.[c]		Scott, Campbell, and Anderson counties, Tenn.[d]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	1.4	Decade measurements of 180 trees with varying stumps 22 to 242 years old.	(e)	Decade measurements on 507 2-foot stumps 143 to 200 years old.	.....	Decade measurements on 56 2.5 to 3.4 foot stumps 119 to 312 years old.	.....	Decade measurements on 132 3-foot stumps 145 to 250 years old.
20 years	3.6		1.1		0.7		0.9	
30 years	5.6		2.2		1.7		2.0	
40 years	7.3		3.2		2.6		3.0	
50 years	8.7		4.2		3.4		4.1	
60 years	9.8		5.3		4.3		5.1	
70 years	10.6		6.3		5.3		6.0	
80 years	11.2		7.4		6.3		7.1	
90 years	11.7		8.5		7.2		8.1	
100 years	12.2		9.7		8.1		9.1	
110 years	12.7		11.0		9.1		10.3	
120 years	13.1		12.3		10.1		11.4	
130 years	13.5		13.5		11.1		12.5	
140 years	13.9		14.7		12.0		13.7	
150 years	14.4		15.4		13.0		14.8	
160 years	.....		16.8		14.0		16.1	
170 years	.....		17.8		14.9		17.3	
180 years	.....		18.9		15.8		18.5	
190 years	.....		19.9		16.5		19.7	
200 years	.....		21.0		17.1		20.8	
210 years	.....		.....		.....		21.9	
220 years	.....		.....		.....		22.9	
230 years	.....		.....		.....		23.8	
240 years	.....		.....		.....		24.7	

[a] Hillman Land and Iron Company, A. B. Patterson, 1905.
[b] Commercial Tree Study, Walter Mulford, 1905–6.
[c] Wetmore and Stevenson Lands, F. E. Olmsted, 1901.
[d] New River Tract, F. E. Olmsted, 1901.
[e] A good average for the southern Appalachian region.

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Oak, white—Continued.

Age.	Diameter growth (second).				Height growth (second).			
	Cove and slope.		Ridge.		Cove and slope.		Ridge.	
	Decatur County, Tenn.[a] [b]				Decatur County, Tenn.[a]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.	Height.	Basis.
	Inches.		*Inches.*		*Feet.*		*Feet.*	
10 years	0.9	Decade measurements on 52 2-foot stumps 49 to 108 years old.	1.3	Decade measurements on 11 2.5-foot stumps 47 to 86 years old.	12	357 entries 1 to 108 years old.	11	46 entries 1 to 86 years old.
20 years	3.3		3.4		25		22	
30 years	5.9		5.7		38		32	
40 years	8.3		8.0		51		43	
50 years	10.3		10.0		63		53	
60 years	11.7		11.5		71		63	
70 years	12.6		12.7		75		70	
80 years	13.3		13.4		77		75	
90 years	13.5		14.0		78		78	
100 years	.....		.....		.....		.....	
110 years	.....		.....		.....		.....	
120 years	.....		.....		.....		.....	
130 years	.....		.....		.....		.....	
140 years	.....		.....		.....		.....	
150 years	.....		.....		.....		.....	
160 years	.....		.....		.....		.....	
170 years	.....		.....		.....		.....	
180 years	.....		.....		.....		.....	
190 years	.....		.....		.....		.....	
200 years	.....		.....		.....		.....	
210 years	.....		.....		.....		.....	
220 years	.....		.....		.....		.....	
230 years	.....		.....		.....		.....	
240 years	.....		.....		.....		.....	

[a] Commercial Tree Study, Walter Mulford, 1905–6.
[b] Circular 105, p. 22.

Oak, swamp white.

Age.	Diameter growth.			
	Seedling.		Coppice.	
	Dutchess County, N. Y.[a]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	
10 years	0.5	5-year measurements on 8 3.5-foot stumps 44 to 111 years old.	2.3	5-year measurements on 8 4.5-foot stumps 27 to 63 years old.
20 years	2.7		4.5	
30 years	4.4		6.2	
40 years	5.9		7.6	
50 years	7.1		9.0	
60 years	8.3		10.3	
70 years	9.3		.....	
80 years	10.2		.....	
90 years	.....		.....	

[a] Rogers and Huyler Working Plan, by J. G. Peters, 1905.

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Pine, loblolly.

Age.	Diameter growth.								
	Thicket.						Old field.		
	Berkeley County, S. C.[a]		Eastern Texas.[b]	Calhoun County, Ark.[c]			Berkeley County, S. C.[d]	Eastern Texas.[b e]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Diameter breast-high.	Basis.		Diameter breast-high.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	*Inches.*			*Inches.*	*Inches.*	
10 years	1.0	Decade measurements on 476 2.5-foot stumps 54 to 179 years old.	0.8	1.0	Decade measurements on 673 2-foot stumps 35 to 181 years old.		1.4	4.3	Five-year measurements on 24 trees 5 to 29 years old.
20 years	4.0		2.3	3.1			6.1	7.6	
30 years	7.4		3.9	5.0			10.0	9.3	
40 years	10.5		5.7	6.9			13.3	.....	
50 years	13.0		7.8	8.8			15.9	.....	
60 years	14.9		10.1	10.7			18.1	.....	
70 years	16.4		11.5	12.4			19.9	.....	
80 years	17.7		13.4	14.1			21.5	.....	
90 years	18.9		15.5	15.6			23.0	.....	
100 years	20.0		17.3	17.2			24.5	.....	
110 years	21.1		18.7	18.7			25.9	.....	
120 years	22.0		19.8	20.2			27.2	.....	
130 years	.....		20.8	21.6			28.5	.....	
140 years	.....		21.8	22.9			29.7	.....	
150 years	.....		22.8	24.2			30.7	.....	
160 years	.....		23.7	25.5			31.7	.....	
170 years	.....		24.5	.....			32.6	.....	
180 years	.....		25.3	.....			33.5	.....	
190 years	.....		25.9	.....			34.3	.....	
200 years	.....		26.5	.....			35.1	.....	
210 years	.....		27.1	.....			35.8	.....	
220 years	.....		27.6	.....			36.5	.....	
230 years	.....		28.1	.....			37.2	.....	
240 years	.....		28.6	.....			37.8	.....	
250 years	.....		29.1	.....			38.5	.....	

[a] Cooper River Holdings—Wassamasaw Tract, H. G. Merrill, 1906.
[b] Loblolly Pine Study, by R. Zon, 1903–4.
[c] Stout-Greer Working Plan, by S. J. Record, 1907.
[d] Cooper River Holdings, C. S. Chapman, 1902–3.
[e] Orange, Newton, Montgomery, and San Jacinto counties, Tex.

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Pine, loblolly—Continued.

Age.	Diameter growth.								Height growth.	
	Pure stand on wet prairie.		Pure stand on light soil fairly well drained (prairie).		Mixed with hard woods on poorly drained soil (thicket).		Mixed with hard woods on well drained fertile soil.			
	Eastern Texas.[b]								Berkeley County, S. C.[a]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.
	In.		*In.*		*In.*		*In.*		*Feet.*	
10 years	3.7		2.2		0.9		2.1		12	
20 years	6.7		7.6		2.2		6.1		38	
30 years	8.8		12.8		3.8		9.5		59	
40 years	.....		16.9		5.6		12.4		75	
50 years	.....		20.0		7.8		15.0		86	
60 years	.....		22.3		9.8		17.2		94	
70 years	.....		24.0		11.9		19.3		100	Combination of height on diameter breast-high and diameter breast-high on age.
80 years	.....	Five-year measurements on 10 trees 23 to 41 years old.	.....	Five-year measurements on 30 trees 35 to 72 years old.	13.9	Five-year measurements on 30 trees 54 to 247 years old.	.....	Five-year measurements on 499 trees 16 to 101 years old.	104	
90 years	.....		.....		15.8		.....		108	
100 years	.....		.....		17.4		.....		111	
110 years	.....		.....		18.8		.....		114	
120 years	.....		.....		20.0		.....		117	
130 years	.....		.....		20.9		.....		119	
140 years	.....		.....		21.8		.....		121	
150 years	.....		.....		22.6		.....		122	
160 years	.....		.....		23.3		.....		123	
170 years	.....		.....		24.0		.....		124	
180 years	.....		.....		24.7		.....		124	
190 years	.....		.....		25.3		.....		125	
200 years	.....		.....		25.8		.....		125	
210 years	.....		.....		26.3		.....		126	
220 years	.....		.....		26.8		.....		126	
230 years	.....		.....		27.2		.....		126	
240 years	.....		.....		27.6		.....		127	
250 years	.....		.....		.....		.....		127	

[a] Cooper River Holdings, C. S. Chapman, 1902–3.
[b] Loblolly Pine Study, by R. Zon, 1903–4.

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Pine, longleaf.

Age.	Diameter growth.						
	Coosa County, Ala.[a]		Berkeley County, S. C.[b]	Berkeley County, S. C.[c]		Jasper County, Tex.[d]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	*Inches.*		*Inches.*	
10 years	.....		.....	0.8		.....	
20 years	1.4		1.2	2.2		1.5	
30 years	2.8		3.0	3.9		3.0	
40 years	4.5		4.9	5.5		4.7	
50 years	6.2		6.7	7.1		6.3	
60 years	7.9		8.6	8.5		8.0	
70 years	9.6		10.5	10.0		9.5	
80 years	11.2		12.4	11.3		10.9	
90 years	12.6		14.1	12.6		12.2	
100 years	14.0		15.5	13.9		13.3	
110 years	15.2		16.6	15.1		14.3	
120 years	16.3		17.6	16.4		15.3	
130 years	17.4		18.4	17.6		16.3	
140 years	18.5		19.2	18.7		17.1	
150 years	19.6		20.0	19.6		17.9	
160 years	20.6	Decade measurements on 265 stumps of various heights and diameters.	20.7	20.4	Decade measurements on 234 2.5-foot stumps 70 to 204 years old	18.7	Decade measurements on 1,292 stumps of various heights and diameters.
170 years	21.5		21.4	21.0		19.4	
180 years	22.4		22.2	21.5		20.0	
190 years	23.2		22.9	21.8		20.7	
200 years	24.0		23.6	22.5		21.4	
210 years	24.7		24.3	.....		22.1	
220 years	25.4		25.0	.....		22.7	
230 years	26.0		25.6	.....		23.4	
240 years	26.7		26.3	.....		24.0	
250 years	27.3		26.9	.....		24.7	
260 years	27.9		.....	.....		25.4	
270 years	28.5		.....	.....		26.1	
280 years	29.1		.....	.....		26.7	
290 years	29.7		.....	.....		27.4	
300 years	30.3		.....	.....		28.1	
310 years	.....		.....	.....		28.8	
320 years	.....		.....	.....		29.4	
330 years	.....		.....	.....		29.9	
340 years	.....		.....	.....		30.5	
350 years	.....		.....	.....		31.0	
360 years	.....		.....	.....		31.6	
370 years	.....		.....	.....		32.0	
380 years	.....		.....	.....		32.6	
390 years	.....		.....	.....		33.1	
400 years	.....		.....	.....		33.6	

[a] Kaul Tract, F. W. Reed, 1903–4.
[b] Cooper River Holdings, C. S. Chapman, 1902–3.
[c] Cooper River Holdings, Wassamasaw Tract, H. G. Merrill, 1906.
[d] Houston Oil Lands, by F. W. Reed, G. E. Clement, H. M. Curran, A. E. Cohoon, 1902–3.

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Pine, longleaf—Continued.

Age.	Diameter growth (second).							
	Jasper County, Tex.[a]				Newton County, Tex.[a]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
20 years	1.6	Decade measurements on 1,533 stumps of various heights and diameters.	1.5	Decade measurements on 507 2-foot stumps 21 to 91 years old	1.5	Decade measurements on 907 stumps of various heights and diameters.	2.8	Decade measurements on 65 2-foot stumps 12 to 117 years old
30 years	3.4		3.1		3.0		5.8	
40 years	5.2		4.9		4.4		8.4	
50 years	7.1		6.8		6.0		10.4	
60 years	8.7		8.6		7.3		11.6	
70 years	10.1		10.1		8.7		12.7	
80 years	11.3		11.5		10.1		13.7	
90 years	12.4		12.8		11.3		14.5	
100 years	13.3		13.9		12.5		15.2	
110 years	14.2		.....		13.5		15.8	
120 years	15.0		.....		14.4		16.3	
130 years	16.0		.....		15.3		.....	
140 years	16.9		.....		16.2		.....	
150 years	17.8		.....		17.0		.....	
160 years	18.8		.....		17.9		.....	
170 years	19.8		.....		18.5		.....	
180 years	20.8		.....		19.1		.....	
190 years	21.8		.....		19.7		.....	
200 years	22.8		.....		20.3		.....	
210 years	23.5		.....		20.9		.....	
220 years	24.2		.....		21.5		.....	
230 years	24.8		.....		22.2		.....	
240 years	25.4		.....		22.9		.....	
250 years	25.9		.....		23.5		.....	
260 years	26.4		.....		24.0		.....	
270 years	27.0		.....		24.5		.....	
280 years	27.8		.....		24.9		.....	
290 years	28.4		.....		25.2		.....	
300 years	29.2		.....		25.7		.....	
310 years	30.0		.....		26.0		.....	
320 years	30.9		.....		26.4		.....	
330 years	31.8		.....		26.9		.....	
340 years	32.8		.....		27.4		.....	
350 years	33.9		.....		28.0		.....	
360 years	35.0		.....		28.4		.....	
370 years	36.2		.....		29.0		.....	
380 years	37.3		.....		29.6		.....	
390 years	38.5		.....		30.1		.....	
400 years	39.6		.....		30.7		.....	

[a] Houston Oil Lands, by F. W. Reed, G. E. Clement, H. M. Curran, A. E. Cohoon, 1902-3.

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Pine, longleaf—Continued.

Age.	Diameter growth.				Height growth.			
	Hardin County, Tex.[a]		Jasper, Hardin, and Newton counties, Tex.[b]		Berkeley County, S. C.[b]		Jasper, Hardin, and Newton counties, Tex.[a]	
							Camp W.	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.	Height.	Basis.
	Inches.		*Inches.*		*Feet.*		*Feet.*	
10 years	.....		.....		4		9	
20 years	1.8		1.7		17		21	
30 years	3.5		3.3		29		36	
40 years	5.2		5.0		41		50	
50 years	7.0		6.6		52		63	
60 years	8.7		8.2		62		74	
70 years	10.2		9.6		71		82	
80 years	11.6		10.8		78		88	
90 years	12.6		12.0		83		92	
100 years	13.6		13.1		86		95	
110 years	14.6		14.2		89		97	
120 years	15.4		15.1		91		99	
130 years	16.1		16.0		93		100	
140 years	16.8		16.8		94	Combination of height on diameter breast-high and diameter breast-high on age.	101	Combination of height on diameter breast-high and diameter breast-high on age.
150 years	17.5	Decade measurements on 1,918 stumps of various heights and diameters.	17.6	Decade measurements on 5,656 stumps of various heights and diameters.	95		102	
160 years	18.2		18.3		96		103	
170 years	18.8		19.0		97		104	
180 years	19.4		19.8		98		104	
190 years	20.0		20.5		99		105	
200 years	20.5		21.2		100		105	
210 years	21.0		21.9		101		106	
220 years	21.4		22.6		101		107	
230 years	21.9		23.2		102		107	
240 years	22.5		23.9		103		107	
250 years	23.1		24.5		103		107	
260 years	23.9		25.1		.....		108	
270 years	24.6		25.7		.....		108	
280 years	25.4		26.3		.....		109	
290 years	26.1		26.9		.....		109	
300 years	26.8		27.5		.....		109	
310 years	27.5		28.0		.....		110	
320 years	28.1		28.6		.....		110	
330 years	28.5		29.1		.....		110	
340 years	28.9		29.6		.....		110	
350 years	29.3		30.2		.....		111	
360 years	29.8		30.7		.....		111	
370 years	30.2		31.2		.....		112	
380 years	30.5		31.7		.....		112	
390 years	30.9		32.2		.....		113	
400 years	31.3		32.6		.....		113	

[a] Houston Oil Lands, by F. W. Reed, G. E. Clement, H. M. Curran, A. E. Cohoon, 1902–3.
[b] Cooper River Holdings, C. S. Chapman, 1902–3.

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Pine, longleaf—Continued.

Age.	Height growth.							
	Jasper, Hardin, and Newton counties, Tex.[a]							
	Camp X.		Camp Y.		Camp Z.		All camps.	
	Height.	Basis.	Height.	Basis.	Height.	Basis.	Height.	Basis.
	Feet.		*Feet.*		*Feet.*		*Feet.*	
10 years	7		11		7		9	
20 years	15		23		15		19	
30 years	27		39		25		32	
40 years	38		54		35		45	
50 years	49		67		45		56	
60 years	60		78		54		67	
70 years	69		86		62		75	
80 years	77		92		69		82	
90 years	83		95		76		87	
100 years	88		98		83		91	
110 years	92		99		88		94	
120 years	95		100		92		97	
130 years	98		101		96		99	
140 years	101	Combination of height on diameter breast-high and diameter breast-high age.	102	Combination of height on diameter breast-high and diameter breast-high on age.	100	Combination of height on diameter breast-high and diameter breast-high on age.	101	Combination of height on diameter breast-high and diameter breast-high on age.
150 years	103		102		103		103	
160 years	105		103		106		104	
170 years	107		104		107		106	
180 years	109		105		108		107	
190 years	110		106		109		108	
200 years	111		107		110		109	
210 years	112		108		110		110	
220 years	113		109		111		110	
230 years	113		109		112		111	
240 years	114		110		113		111	
250 years	114		110		114		112	
260 years	114		110		114		112	
270 years	114		110		115		112	
280 years	114		110		116		113	
290 years	115		110		116		113	
300 years	115		111		117		113	
310 years	116		111		117		114	
320 years	116		111		118		114	
330 years	116		111		118		115	
340 years	117		111		119		115	
350 years	117		111		119		115	
360 years	117		111		120		116	
370 years	118		111		120		116	
380 years	118		111		121		116	
390 years	118		111		121		116	
400 years	118		111		122		116	

[a] Houston Oil Lands, by F. W. Reed, G. E. Clement, H. M. Curran, A. E. Cohoon, 1902–3.

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Pine, jack.

Age.	Diameter growth.							
	Class A; quality, good, subdominant.		Quality, good, medium.		Quality, good, suppressed.		Quality, poor, subdominant.	
	Hubbard County, Minn. [a]							
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	1.7	Decade measurements on 44 4.5-foot stumps 22 to 49 years old.	1.4	Decade measurements on 45 4.5-foot stumps 22 to 46 years old.	1.2	Decade measurements on 45 4.5-foot stumps 18 to 46 years old.	1.0	Decade measurements on 83 4.5-foot stumps 22 to 81 years old.
20 years	4.4		3.8		3.0		3.3	
30 years	6.2		5.1		4.0		4.8	
40 years	7.5		6.1		4.7		6.0	
50 years	8.5		7.0		.....		7.0	
60 years	.....		.....		.....		7.8	
70 years	.....		.....		.....		8.6	
80 years	.....		.....		.....		9.3	

Age.	Diameter growth.									
	Quality, poor, medium.		Quality, poor, suppressed.		Classes B and C; quality, good, dominant.		Quality, poor, dominant.		Class D; open grown.	
	Hubbard County, Minn. [a]									
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*		*Inches.*	
10 years	0.9	Decade measurements on 80 4.5-foot stumps 20 to 76 years old.	0.8	Decade measurements on 82 4.5-foot stumps 21 to 80 years old.	1.8	Decade measurements on 74 4.5-foot stumps 23 to 90 years old.	1.1	Decade measurements on 91 4.5-foot stumps 22 to 102 years old.	1.7	Decade measurements on 60 4.5-foot stumps 22 to 82 years old.
20 years	2.8		2.2		5.5		3.9		5.1	
30 years	4.2		3.2		7.9		5.9		7.9	
40 years	5.1		4.1		9.4		7.4		10.2	
50 years	6.0		4.9		10.8		8.7		11.8	
60 years	6.5		5.5		.....		9.9		13.1	
70 years	7.1		6.1		.....		10.9		14.2	
80 years	7.5		.....		.....		11.8		15.3	

[a] Northern Pacific Railroad Tie Study, by H. H. Chapman, 1905.

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Pine, red.

Age.	Diameter growth.							
	Ridge.		Ravine.		Jack pine mixture; quality, good.		Jack pine mixture; quality, poor.	
	Bayfield County, Wis.[a]				Itasca County, Minn.[a]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	0.5	Decade measurements on 140 1-foot stumps 111 to 202 years old.	1.0	Decade measurements on 99 1-foot stumps 108 to 203 years old.	0.4	Decade measurements on 26 2.5-foot stumps 21 to 44 years old.	.....	Decade measurements on 18 2.5-foot stumps 19 to 77 years old.
20 years	2.7		3.3		2.4		1.7	
30 years	5.2		5.8		4.2		3.4	
40 years	7.5		8.2		5.7		4.8	
50 years	9.3		10.3		.....		6.0	
60 years	11.0		12.1		.....		6.9	
70 years	12.5		13.8		.....		7.8	
80 years	13.7		15.3		.....		.....	
90 years	14.8		16.5		.....		.....	
100 years	15.9		17.6		.....		.....	
110 years	17.0		18.7		.....		.....	
120 years	18.0		19.7		.....		.....	
130 years	19.1		20.7		.....		.....	
140 years	20.2		21.7		.....		.....	
150 years	21.2		22.6		.....		.....	
160 years	22.2		23.4		.....		.....	
170 years	23.1		24.2		.....		.....	
180 years	24.0		24.9		.....		.....	
190 years	24.9		25.5		.....		.....	
200 years	25.7		26.1		.....		.....	

Age.	Diameter growth.					
	Classes 2A and 4.[b]		Classes 1, 2B, and 3; open grown and dominant.		Class 2.	
	Itasca County, Minn.[a]					
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*	
10 years	0.3	Decade measurements on 228 1 to 1.5 foot stumps 72 to 126 years old.	0.9	Decade measurements on 190 1 to 1.5 foot stumps 78 to 163 years old.	0.2	Decade measurements on 52 1 to 1.5 foot stumps 84 to 107 years old.
20 years	2.0		3.6		1.2	
30 years	3.9		6.5		2.0	
40 years	5.7		9.0		3.1	
50 years	7.3		11.1		4.2	
60 years	8.7		12.7		5.6	
70 years	10.0		13.9		7.2	
80 years	11.1		15.0		9.0	
90 years	12.1		16.0		10.9	
100 years	12.8		16.9		12.9	
110 years	13.5		17.9		.....	
120 years	14.0		18.8		.....	
130 years	14.5		19.7		.....	
140 years	.....		20.6		.....	
150 years	.....		21.5		.....	
160 years	.....		22.3		.....	
170 years	.....		.....		.....	
180 years	.....		.....		.....	
190 years	.....		.....		.....	
200 years	.....		.....		.....	

[a] Red Pine Study, by H. H. Chapman, 1905.

[b] Averages of crowded stands.

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Pine, scrub.

Age.	Diameter growth.				Height growth.			
	Dominant.		Intermediate and suppressed.					
	Montgomery County, Md.[a]							
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.	Height.	Basis.
	Inches.		*Inches.*		*Feet.*		*Feet.*	
10 years	2.4	104 trees 5 to 56 years old.	1.9	43 trees 5 to 56 years old.	17	801 sectional age counts (about 200 trees).	25	Combined growth-diameter (dominant trees) and height curves.
20 years	2.8		3.6		33		42	
30 years	6.5		4.8		46		48	
40 years	7.9		5.5		55		52	
50 years	8.9		6.2		63		54	
60 years	10.1		.....		.....		56	

[a] Scrub Pine Study, by W. D. Sterrett, 1905.

Pine, shortleaf.

Age.	Diameter growth.			
	Calhoun County, Ark.[a]		Reynolds County, Mo.[a]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	
10 years	0.8	Decade measurements on 398 2-foot stumps 48 to 239 years old.	.....	Decade measurements on 231 2-foot stumps 102 to 254 years old.
20 years	2.5		1.6	
30 years	4.2		3.4	
40 years	5.8		5.1	
50 years	7.5		6.7	
60 years	9.0		8.2	
70 years	10.4		9.6	
80 years	11.9		10.7	
90 years	13.2		11.8	
100 years	14.6		12.7	
110 years	15.8		13.6	
120 years	16.9		14.4	
130 years	18.0		15.2	
140 years	18.9		15.9	
150 years	19.8		16.6	
160 years	20.6		17.3	
170 years	21.3		18.0	
180 years	22.0		18.8	
190 years	22.7		.....	
200 years	23.4		.....	

[a] Stout-Greer Working Plan, by S. J. Record, 1907.

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Pine, spruce.

Age.	Diameter growth.	
	Berkeley County, S. C.[a]	
	Diameter breast-high.	Basis.
	Inches.	
10 years		
20 years	1.4	Decade measurements on 70 2.5-foot stumps 78 to 127 years old.
30 years	3.3	
40 years	5.6	
50 years	8.1	
60 years	10.7	
70 years	13.2	
80 years	15.7	
90 years	17.9	
100 years	19.4	
110 years	20.6	
120 years	21.7	

[a] Cooper River Holdings, Wassamasaw Tract, H. G. Merrill, 1906.

Pine, sugar.

Age.	Diameter growth.		Height growth.	
	Butte County, Cal.[a]			
	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Feet.*	
10 years	0.7		7	
20 years	2.5		15	
30 years	4.1		22	
40 years	5.8		29	
50 years	7.8		39	
60 years	9.9	Decade measurements on 144 2.5-foot stumps 25 to 311 years old.	49	Combination of growth-diameter and height curves.
70 years	12.2		60	
80 years	14.4		70	
90 years	16.5		81	
100 years	18.7		92	
110 years	20.9		103	
120 years	23.0		113	
130 years	24.9		122	
140 years	26.6		128	
150 years	28.2		134	
160 years	29.3		138	
170 years	30.4		140	
180 years	31.4		143	
190 years	32.0		144	
200 years	32.4		144	

[a] Sugar Pine Study, by A. W. Cooper, 1904.

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Pine, white.

Age.	Diameter growth.							
	Cove.				Slope.			
	St. Louis County, Minn.[a]		Johnson County, Tenn.[b]		Polk County, Tenn.[b]		Mitchell County, N. C.[b]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	.....	Decade measurements on 8,764 stumps of various heights and diameters.	.....	Decade measurements on 174 3-foot stumps 103 to 200 years old.	.....	Decade measurements on 201 2-foot stumps.	0.2	Decade measurements on 504 2.5-foot stumps.
20 years	2.8		1.9		2.2		2.4	
30 years	5.3		5.6		4.4		4.7	
40 years	7.6		8.5		6.4		6.9	
50 years	9.2		11.3		8.5		9.1	
60 years	10.7		13.9		10.7		11.2	
70 years	11.9		16.5		12.7		13.2	
80 years	13.0		18.6		14.5		15.0	
90 years	13.9		20.5		16.1		16.6	
100 years	14.8		22.1		17.7		18.0	
110 years	15.5		23.6		19.1		19.3	
120 years	16.3		25.1		20.4		20.4	
130 years	17.0		26.3		21.7		21.5	
140 years	17.7		27.5		22.8		22.5	
150 years	18.3		28.7		23.8		23.5	
160 years	19.0		30.0		24.8		24.5	
170 years	19.5		31.1		25.8		25.5	
180 years	20.4		32.3		26.8		26.4	
190 years	21.0		33.4		27.7		27.2	
200 years	21.7		34.5		28.6		27.9	
210 years	22.4		.....		.....		.....	
220 years	23.0		.....		.....		.....	
230 years	23.5		.....		.....		.....	
240 years	24.0		.....		.....		.....	
250 years	24.5		.....		.....		.....	
260 years	25.0		.....		.....		.....	
270 years	25.4		.....		.....		.....	
280 years	25.8		.....		.....		.....	
290 years	26.2		.....		.....		.....	
300 years	26.6		.....		.....		.....	

[a] White Pine Study, by C. S. Chapman, 1903.
[b] Commercial Tree Study, by Walter Mulford, 1905–6.

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Poplar, yellow.

Age.	Diameter growth.							
	Cove.							
	Polk and Monroe counties, Tenn.[a]		Scott, Campbell, and Anderson counties, Tenn.[a]		Haywood County, N. C.[a]		Wyoming County, W. Va.[a]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	1.2		1.0		1.6		1.2	
20 years	3.4		3.0		4.6		3.0	
30 years	5.4		5.0		7.7		4.7	
40 years	7.3		6.9		10.5		6.5	
50 years	8.9		8.7		12.8		8.0	
60 years	10.4	Decade	10.4	Decade	14.7	Decade	9.5	Decade
70 years	11.9	measure-	12.1	measure-	16.1	measure-	10.9	measure-
80 years	13.4	ments	13.8	ments	17.3	ments	12.3	ments
90 years	14.9	on	15.5	on	18.5	on	13.8	on
100 years	16.3	132	17.0	181	19.5	67	15.1	33
110 years	17.7	2.5-foot	18.5	3-foot	20.3	3-foot	16.4	4.5-foot
120 years	19.1	stumps	20.0	stumps	21.1	stumps	17.8	stumps
130 years	20.3	24 to 200	21.4	23 to 200	21.7	38 to 200	19.1	152 to 200
140 years	21.5	years	22.7	years	22.4	years	20.4	years
150 years	22.7	old.	23.9	old.	23.0	old.	21.6	old.
160 years	23.7		24.9		23.7		22.8	
170 years	24.6		25.8		24.3		23.8	
180 years	25.5		26.7		24.9		24.7	
190 years	26.3		27.5		25.5		25.7	
200 years	27.1		28.3		26.1		26.4	

Age.	Diameter growth.							
	Slope.		Quality I (seedlings).[b]		Quality II (seedlings).[b]		Sprouts.[b]	
	Wyoming County, W. Va.[a]		Fairfax County, Va.[c]					
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	1.1		2.9		1.9		3.6	
20 years	3.8		6.5		4.6		7.4	
30 years	6.0		9.7		7.4		10.2	
40 years	7.4		12.6		10.2		12.7	
50 years	8.7		15.2		13.0		15.0	
60 years	9.8	Decade	17.3	827	15.8	925	.....	346
70 years	11.0	measure-	19.2	decade	18.3	decade	.....	decade
80 years	12.0	ments	.....	measure-	20.6	measure-	.....	measure-
90 years	13.1	on	.....	ments	22.7	ments	.....	ments
100 years	14.1	42	.....	on 207	24.6	on 209	.....	on 95
110 years	15.2	4.5-foot	.....	1 to 2 foot	.....	1 to 2 foot	.....	1 to 2 foot
120 years	16.3	stumps	.....	stumps	.....	stumps	.....	stumps
130 years	17.4	29 to 199	.....	10 to 71	.....	17 to 102	.....	17 to 102
140 years	18.5	years	.....	years	.....	years	.....	years
150 years	19.7	old.	.....	old.	.....	old.	.....	old.
160 years	20.4		.....		.....		.....	
170 years	21.1		.....		.....		.....	
180 years	21.8		.....		.....		.....	
190 years	22.3		.....		.....		.....	
200 years	22.5		.....		.....		.....	

[a] Commercial Tree Study, Walter Mulford, 1905–6.
[b] Taken in pure even-aged stands of normal or almost normal density.
[c] Second Growth Yellow Poplar Study, by W. W. Ashe, 1907.

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Poplar, yellow—Continued.

Age.	Height growth.					
	Quality I (seedlings).		Quality II (seedlings).		Sprouts.	
	Fairfax County, Va.[a]					
	Height.	Basis.	Height.	Basis.	Height.	Basis.
	Feet.		*Feet.*		*Feet.*	
10 years	27	358 sectional age counts on 207 trees.	20	326 sectional age counts on 209 trees.	32	188 sectional age counts on 95 trees.
20 years	50		36		53	
30 years	64		50		70	
40 years	74		64		.....	
50 years	83		78		.....	
60 years	.....		.....		.....	
70 years	.....		.....		.....	
80 years	.....		.....		.....	
90 years	.....		.....		.....	
100 years	.....		.....		.....	
110 years	.....		.....		.....	
120 years	.....		.....		.....	
130 years	.....		.....		.....	
140 years	.....		.....		.....	
150 years	.....		.....		.....	
160 years	.....		.....		.....	
170 years	.....		.....		.....	
180 years	.....		.....		.....	
190 years	.....		.....		.....	
200 years	.....		.....		.....	

[a] Second Growth Yellow Poplar Study, by W. W. Ashe, 1907.

Spruce, black.

Age.	Diameter growth.	
	St. Louis County, Minn.[a]	
	Diameter breast-high.	Basis.
	Inches.	
10 years	.....	Decade measurements on 93 4.5-foot stumps 100 to 271 years old.
20 years	.....	
30 years	.....	
40 years	0.5	
50 years	1.1	
60 years	1.5	
70 years	1.9	
80 years	2.2	
90 years	2.4	
100 years	2.7	
110 years	2.9	

[a] White Pine Study, by C. S. Chapman, 1903.

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Spruce, Engelmann.

Age.	Diameter growth.				Height growth.	
	Gunnison County, Colo.[a]		Uinta National Forest, Utah. Gunnison, Leadville, and Uncompahgre National Forests, Colo.[b]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Inches.*		*Feet.*	
10 years					1.5	
20 years	1.2				2.5	
30 years	2.3				4.0	
40 years	3.6		0.8		5.5	
50 years	4.8		1.6		8.0	
60 years	5.9		2.5		11.0	
70 years	7.0		3.4		16.0	
80 years	7.9	Decade measurements at 2 feet on 43 trees 68 to 225 years old.	4.3	Decade measurements on 87 2-foot stumps 119 to 360 years old.	22.0	450 sectional age counts on 104 trees.
90 years	8.7		5.2		29.0	
100 years	9.4		6.2		36.0	
110 years	10.0		7.0		43.0	
120 years	10.6		7.9		50.0	
130 years	11.1		8.6		55.0	
140 years	11.6		9.4		60.0	
150 years	12.1		10.1		63.0	
160 years	12.5		10.8		66.0	
170 years	12.9		11.5		69.0	
180 years	13.3		12.2		72.0	
190 years	13.7		12.9		75.0	
200 years	14.0		13.7		78.0	
210 years					80.0	
220 years					83.0	
230 years					85.0	
240 years					90.0	
250 years						

Age.	Height growth.				
	Gunnison County, Colo.[a]	Density 1.		Density 0.5.	
		Salt Lake National Forest, Idaho.[cd]			
	Height.	Height.	Basis.	Height.	Basis.
	Feet.	*Feet.*		*Feet.*	
10 years	2.2	1.3		1.0	
20 years	4.0	3.8		3.0	
30 years	5.4	7.0		8.0	
40 years	6.7	10.0		12.5	
50 years	8.4				
60 years	10.2				
70 years	11.5				
80 years	12.3				
90 years	12.9				
100 years	13.5				
110 years					
120 years			9 trees.		10 trees.
130 years					
140 years					
150 years					
160 years					
170 years					
180 years					
190 years					
200 years					
210 years					
220 years					
230 years					
240 years					
250 years					

[a] Planting Reconnoissance, S. B. Detweiler, 1905.
[b] Engelmann Spruce Study, by J. W. Foster, 1907.
[c] Planting Reconnoissance, J. M. Fetherolf.
[d] Pure conifer type, elevation 8,750 feet.

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Spruce, red.

Age.	Diameter growth.			
	Piscataquis County, Me.[a]			
	Diameter breast-high.	Basis.	Spruce slope—Quality II.	
			Diameter breast-high.	Basis.
	Inches.		*Inches.*	
20 years	0.1		0.6	
30 years	0.6		2.4	
40 years	0.8		4.1	
50 years	1.1		5.3	
60 years	1.5		6.2	
70 years	1.8	Decade	6.8	Decade
80 years	2.2	measure-	.....	measure-
90 years	2.7	ments	.....	ments
100 years	3.2	on	.....	on
110 years	3.7	274	.....	39
120 years	4.3	1 to 2 foot	.....	4.5-foot
130 years	4.9	stumps	.....	stumps
140 years	5.5	112 to 300	.....	49 to 197
150 years	6.2	years old.	.....	years old.
160 years	6.9		.....	
170 years	7.6		.....	
180 years	8.3		.....	
190 years	9.0		.....	
200 years	9.7		.....	

[a] Maine Forest Study, R. S. Hosmer, 1902. Great Northern Paper Company, H. Grinnell, 1902.

Spruce, white.

Age.	Diameter growth.		Height growth.	
	St. Louis County, Minn.[a]			
	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Feet.*	
10 years	.....		20	
20 years	.....		28	
30 years	.....		43	
40 years	1.2		50	
50 years	2.5	Decade	.....	
60 years	3.3	measure-	.....	
70 years	4.2	ments	.....	
80 years	4.9	on	.....	
90 years	5.6	50	.....	218 trees.
100 years	6.0	4.5-foot	.....	
110 years	6.5	stumps	.....	
120 years	7.0	59 to 167	.....	
130 years	7.5	years old.	.....	
140 years	8.0		.....	
150 years	8.8		.....	
160 years	9.6		.....	
170 years	10.5		.....	

[a] White Pine Study, by C. S. Chapman, 1903.

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Tamarack.

Age.	Diameter Growth.					
	Upland.				Swamp.	
	St. Louis County, Minn.[a]					
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*	
10 years	0.5	Decade measurements on 227 4.5-foot stumps 96 to 227 years old.	0.1	Decade measurements on 31 1.5 to 2 foot stumps 111 to 149 years old.	0.1	Decade measurements on 85 2-foot stumps 127 to 232 years old.
20 years	1.5		1.7		1.6	
30 years	2.5		3.4		2.9	
40 years	3.3		4.9		4.0	
50 years	4.2		6.1		5.0	
60 years	4.7		7.0		5.8	
70 years	5.3		7.8		6.4	
80 years	5.9		8.5		6.9	
90 years	6.5		9.2		7.4	
100 years	6.9		10.0		7.8	
110 years	7.5		10.8		8.4	
120 years	8.0		11.5		9.0	
130 years	8.6		12.3		9.7	
140 years	9.4		13.0		10.4	
150 years	10.6		13.7		11.0	
160 years	12.2		.....		.....	
170 years	13.4		.....		.....	
180 years	14.2		.....		.....	
190 years	15.0		.....		.....	
200 years	15.8		.....		.....	

[a] Northern Pacific Railroad Tie Study, by H. H. Chapman, 1905.

Walnut, black.

Age.	Diameter growth.		Height growth.	
	Eastern Nebraska.[a]			
	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Feet.*	
10 years	2.6	5-year measurements on 23 1-foot stumps 15 to 43 years old.	18	7-foot sectional measurements on 23 trees 15 to 43 years old.
20 years	5.2		30	
30 years	6.7		42	
40 years	7.5		51	
50 years	7.8		57	

[a] Plantations, L. C. Miller, 1904.

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Birch, paper—Yield per acre—Pure (100 per cent) birch stands.

PENOBSCOT, PISCATAQUIS, SOMERSET, AND FRANKLIN COUNTIES, ME.

[Data gathered by R. L. Marston for Paper Birch Study 1903–1907.]

Age.	Quality I.				
	Average diameter breast-high.	Average height.	Total yield.	Yield of trees 6 inches and over, in per-centage of total yield.	Basis.
	Inches.	*Feet.*	*Cubic feet.*	*Per cent.*	*Sample plots.*
15 years	2.3	24	710	0	1
20 years	3.4	33	1,020	4	3
25 years	4.5	41	1,340	27	1
30 years	5.6	48	1,700	46	1
35 years	6.4	54	2,090	63	2
40 years	7.2	58	2,520	75	.....
45 years	7.8	62	2,950	85	.....
50 years	8.4	65	3,340	91	1
55 years	8.8	68	3,660	96	1
60 years	9.2	70	3,940	98	4
65 years	9.6	72	4,190	100	4
70 years	10.0	74	4,450	100	2

Birch, paper—Yield per acre—Pure (100 per cent) birch stands.

PENOBSCOT, PISCATAQUIS, SOMERSET, AND FRANKLIN COUNTIES, ME.

[Data gathered by R. L. Marston for Paper Birch Study, 1903–1907.

Age.	Quality II.				
	Average diameter breast-high.	Average. height.	Total yield.	Yield of trees 6 inches and over, in per-centage of total yield.	Basis.
	Inches.	*Feet.*	*Cubic feet.*	*Per cent.*	*Sample plots.*
15 years	1.8	21	410	0	1
20 years	2.6	28	580	0	5
25 years	3.4	34	770	18	.....
30 years	4.3	40	1,010	35	1
35 years	5.0	45	1,290	50	2
40 years	5.7	49	1,580	63	1
45 years	6.3	53	1,890	73	1
50 years	6.8	56	2,220	82	1
55 years	7.2	59	2,530	89	2
60 years	7.6	61	2,810	94	5
65 years	7.9	64	3,060	97	5
70 years	8.2	66	3,300	100	2

NOTE.—These sample plots were taken in unmanaged stands. All plots with a density less than 50 per cent were discarded. All plots containing less than 40 per cent birch were discarded, and the remainder reduced to 100 per cent birch by dividing the actual birch yield by the percentages of the total basal area formed by the birch. Hence the table applies only to pure birch stands of average density (Quality I. 83 per cent, and Quality II, 75 per cent). For the yield of a mixed stand containing, for example, 60 per cent of birch, a corresponding reduction would be made in the yield. The number of trees per acre was exceedingly irregular and was therefore excluded from the table.

The volume given is total stem volume, though the lowest measurement taken in the sample trees was at 4.5 feet, and this disregard for butt swelling makes the yield conservative.

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Gum, blue—Yield per acre—Seedling growth.

CALIFORNIA.

[Data gathered by J. B. Anderson and S. J. Flintham for Eucalyptus Study, 1903 and 1906.]

Age.	Quality I.			Quality II.			Quality III.		
	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.
	Cubic ft.	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
4 years	1,300	1,050	801	800	575	351	350	.....	.....
6 years	2,600	2,250	1,901	1,900	1,550	1,201	1,200	875	550
8 years	3,700	3,250	2,801	2,800	2,350	1,901	1,900	1,450	1,000
10 years	4,600	4,050	3,501	3,500	2,950	2,401	2,400	1,875	1,350
12 years	5,400	4,775	4,151	4,150	3,500	2,851	2,850	2,200	1,550
14 years	6,150	5,425	4,701	4,700	3,975	3,251	3,250	2,500	1,750
16 years	6,800	6,025	5,251	5,250	4,425	3,601	3,600	2,775	1,950
18 years	7,450	6,650	5,851	5,850	4,900	3,951	3,950	3,025	2,100
20 years	8,150	7,200	6,251	6,250	5,275	4,301	4,300	3,275	2,250
22 years	8,800	7,750	6,701	6,700	5,650	4,601	4,600	3,500	2,400
24 years	9,450	8,325	7,201	7,200	6,050	4,901	4,900	3,700	2,500
26 years	10,050	8,850	7,651	7,650	6,425	5,201	5,200	3,950	2,700
28 years	10,700	9,400	8,101	8,100	6,800	5,501	5,500	4,175	2,850
30 years	11,300	9,925	8,551	8,550	7,175	5,801	5,800	4,400	3,000

Gum, blue—Yield per acre—Seedling growth.

CALIFORNIA.

[Data gathered by J. B. Anderson and S. J. Flintham for Eucalyptus Study, 1903 and 1906.]

Age.	Quality I.			Quality II.			Quality III.		
	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.
	Bd. ft.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*
8 years	5,500	4,000	2,501	2,500	.....	.....	.....	.....	.....
10 years	8,500	6,750	5,001	5,000	3,000	1,001	1,000	.....	.....
12 years	12,000	9,750	7,501	7,500	5,500	3,501	3,500	.....	.....
14 years	16,500	13,750	11,001	11,000	8,250	5,501	5,500	.....	.....
16 years	21,000	17,750	14,501	14,500	11,000	7,501	7,500	4,250	1,000
18 years	26,000	21,750	17,501	17,500	13,750	10,001	10,000	6,000	2,000
20 years	31,000	26,250	21,501	21,500	16,750	12,001	12,000	7,250	2,500
22 years	36,000	30,500	25,001	25,000	19,500	14,001	14,000	8,750	3,500
24 years	41,500	35,250	29,001	29,000	22,750	16,501	16,500	10,250	4,000
26 years	46,500	39,500	32,501	32,500	25,500	18,501	18,500	11,750	5,000
28 years	52,000	44,000	36,001	36,300	28,250	20,501	20,500	13,000	5,500
30 years	57,000	48,500	40,001	40,000	31,500	23,001	23,000	14,750	6,500

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Gum, blue—Yield per acre—Sprout growth.

CALIFORNIA.

[Data gathered by J. B. Anderson and S. J. Flintham for Eucalyptus Study, 1903 and 1906.]

Age.	Quality I.			Quality II.			Quality III.		
	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.
	Cu. ft.	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*
2 years	820	700	581	580	440	301	300	180	60
3 years	2,100	1,815	1,531	1,530	1,150	771	770	440	110
4 years	3,300	2,760	2,221	2,220	1,715	1,211	1,210	710	210
5 years	4,200	3,555	2,911	2,910	2,265	1,621	1,620	975	330
6 years	5,000	4,250	3,501	3,500	2,740	1,981	1,980	1,220	460
7 years	5,650	4,825	4,001	4,000	3,145	2,291	2,290	1,445	600
8 years	6,230	5,320	4,411	4,410	3,495	2,581	2,580	1,650	720
9 years	6,780	5,790	4,801	4,800	3,810	2,821	2,820	1,835	850
10 years	7,250	6,200	5,151	5,150	4,110	3,071	3,070	2,015	960
11 years	7,700	6,580	5,461	5,460	4,375	3,291	3,290	2,180	1,070
12 years	8,100	6,925	5,751	5,750	4,615	3,481	3,480	2,320	1,160
13 years	8,480	7,250	6,021	6,020	4,835	3,651	3,650	2,445	1,240
14 years	8,820	7,560	6,301	6,300	5,055	3,811	3,810	2,560	1,310
15 years	9,160	7,865	6,571	6,570	5,270	3,971	3,970	2,670	1,370
16 years	9,500	8,150	6,801	6,800	5,450	4,101	4,100	2,760	1,420

Gum, blue—Yield per acre—Sprout growth.

CALIFORNIA.

[Data gathered by J. B. Anderson and S. J. Flintham for Eucalyptus Study, 1903 and 1906.]

Age.	Quality I.			Quality II.			Quality III.		
	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.
	B. ft.	*B. ft.*	*B. ft.*	*B. ft.*	*B. ft.*	*B. ft.*	*B. ft.*	*B. ft.*	*B. ft.*
3 years	500	.....	.....	.....	.....	.....	.....	.....	.....
4 years	2,000	.....	.....	.....	.....	.....	.....	.....	.....
5 years	4,000	2,750	1,501	1,500	.....	.....	.....	.....	.....
6 years	6,500	5,500	4,501	4,500	2,750	1,001	1,000	.....	.....
7 years	11,500	9,500	7,501	7,500	5,500	3,501	3,500	.....	.....
8 years	16,500	13,750	11,001	11,000	8,500	6,001	6,000	3,250	500
9 years	21,000	17,500	14,001	14,000	11,000	8,001	8,000	5,250	2,500

Hardwoods (second growth)—Yield per acre.

STEWART AND DECATUR COUNTIES, TENN.

[Data gathered by R. Zon for Circular 118—Management of Second Growth in the Southern Appalachians. 1907.]

Age.	Average trees per acre.	Stem volume.		Lumber (Doyle-Scribner).		Ties.	
		Ridge.	Slope.	Ridge.	Slope.	Ridge.	Slope.
	Number.	*Cubic ft.*	*Cubic ft.*	*Board ft.*	*Board ft.*	*Number.*	*Number.*
10 years	1,340	740	560	.....	.....	.....	.....
20 years	960	1,355	1,200	.....	.....	.....	.....
30 years	700	1,715	1,700	220	330	.....	.....
40 years	500	1,945	2,015	660	885	.....	.....
50 years	355	2,105	2,215	1,520	1,795	.....	.....
60 years	255	2,200	2,340	2,780	3,200	200	213
70 years	180	.....	2,440	.....	.....	.....	222
80 years	140	.....	.....	.....	.....	.....	.....

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Pine, loblolly—Yield per acre.[a]

MARYLAND.

[Data gathered by W. D. Sterrett for Loblolly Pine Study, 1907.]

Age.	Quality I.							
	Trees per acre.		Average diameter of dominant trees.	Average height of dominant trees.	Yield.		Basis	
	Dominant.	Total.			Total.	Box boards[b]	Plots.	Age.
	Number.	*Number.*	*Inches.*	*Feet.*	*Cu. ft.*	*Bd. ft.*	*Number.*	*Years.*
15 years	860	1,500	4.9	32	2,100	3,400	.....	.....
20 years	550	840	6.5	43	3,000	9,000	17	12
25 years	400	560	7.8	52	3,650	15,400	15	17
30 years	310	400	8.9	59	4,200	18,900	8	29
35 years	250	320	9.8	65	4,500	21,800	8	40
40 years	200	260	10.6	70	4,750	24,100	.....	.....

Age	Quality II.							
	Trees per acre.		Average diameter of dominant trees.	Average height of dominant trees.	Yield.		Basis.	
	Dominant.	Total.			Total.	Box boards[b]	Plots.	Age.
	Number.	*Number.*	*Inches.*	*Feet.*	*Cu. ft.*	*Bd. ft.*	*Number.*	*Years.*
15 years	1,040	1,840	3.6	28	1,550	1,400	.....	.....
20 years	750	1,420	4.9	35	2,100	3,800	6	12
25 years	550	1,000	6.1	41	2,700	7,400	5	21
30 years	400	700	7.2	47	3,100	11,300	8	31
35 years	310	500	8.1	52	3,300	14,000	2	39
40 years	250	370	8.9	57	3,550	15,800	2	48

[a] Approximate yield in pure, unmanaged, fully stocked stands on old fields.
[b] Round or "waney" edged boards—saw cut. Square-edged material would show a smaller yield.

NOTE.—This table is based on sample plots of limited area. Extended areas could hardly be counted on for such a uniformly dense stand unless openings were carefully planted up and the forest kept under scientific control. On the other hand, the natural stands contained about 10 per cent of other species, which are left out of the total as a factor of safety.

The yields were approximated by means of white-pine volume tables, and 10 per cent was deducted from the yield in box boards against a possible variation between the volumes of bark in the two species and as a further factor of safety.

Pine, loblolly—Yield per acre.[a]

MARYLAND.

[Data gathered by W. D. Sterrett for Loblolly Pine Study, 1907.]

Age.	Quality I.		
	Percentage of total yield in diameter classes.		
	1 to 5 inches.	6 to 9 inches.	10 inches and over.
	Per cent.	*Per cent.*	*Per cent.*
15 years	65	34	1
20 years	32	53	15
25 years	13	59	28
30 years	4	56	40
35 years	1	47	52
40 years	.....	34	66

[a] Proportion of total yield in different diameter classes.

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Pine, loblolly—Yield per acre—Continued.

MARYLAND—Continued.

Age.	Quality II.		
	Percentage of total yield in diameter classes.		
	1 to 5 inches.	6 to 9 inches.	10 inches and over.
	Per cent.	*Per cent.*	*Per cent.*
15 years	78	22	0
20 years	60	40	0
25 years	39	51	10
30 years	23	57	20
35 years	11	58	31
40 years	5	50	45

Pine, loblolly—Yield per acre—All types combined.

EASTERN TEXAS.

[Data gathered by R. Zon for Loblolly Pine Study, 1903–4.]

Age.	Total.		Within each decade.		Annual average within each decade.	
	Cubic ft.	*Board ft.*[a]	*Cubic ft.*	*Board ft.*[a]	*Cubic ft.*	*Board ft.*[a]
10 years	1,650	.....	1,650	.....	165	.....
20 years	2,600	6,500	950	.....	95	.....
30 years	3,200	7,450	600	950	60	95
40 years	3,700	9,300	500	1,850	50	185
50 years	4,150	11,900	450	2,600	45	260
60 years	4,600	14,500	450	2,600	45	260
70 years	5,000	17,100	400	2,600	40	260

[a] Herring log rule.

Pine, scrub—Yield per acre.

MONTGOMERY COUNTY, MD.

[Data gathered by W. D. Sterrett for Scrub Pine Study, 1905.]

Age.	Number of trees.	Total stem.	Firewood.	Peeled pulpwood.	Basis.
		Cubic ft.	*Cords.*	*Cords.*	
15 years	2,510	1,280	12.8	.....	39 sample plots $\frac{1}{4}$ to 1 acre each.
20 years	1,470	2,010	20.1	.....	
25 years	885	2,510	25.1	.....	
30 years	625	2,990	29.9	26.0	
35 years	490	3,450	34.5	30.0	
40 years	420	3,900	39.0	33.9	
45 years	380	4,290	42.9	37.3	
50 years	370	4,650	46.5	40.4	

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Pine, white—Yield per acre.

SOUTHERN NEW HAMPSHIRE.

[Data gathered by L. Margolin for Graded Mill Tallies, 1906.]

Age.	Quality I.					
	Number of trees.	Basal area.	Mean height.	Volume.	Current annual increment.	Mean annual increment.
		Square ft.	*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
25 years	2,430	190	33	3,100	124	124
30 years	1,840	215	41	4,367	253	145
35 years	1,250	230	48	5,850	296	167
40 years	870	238	56	7,033	236	176
45 years	640	243	64	8,000	193	177
50 years	510	246	70	8,767	153	175
55 years	430	249	75	9,475	141	172
60 years	380	252	80	10,100	125	168
65 years	340	255	84	10,633	106	164
70 years	310	258	87	11,100	93	158
75 years	280	261	90	11,567	93	154
80 years	260	263	93	12,000	86	150
85 years	240	266	95	12,383	76	146
90 years	220	268	97	12,767	76	142

Pine, white—Yield per acre.

SOUTHERN NEW HAMPSHIRE.

[Data gathered by L. Margolin for Graded Mill Tallies, 1906.]

Age.	Quality II.					
	Number of trees.	Basal area.	Mean height.	Volume.	Current annual increment.	Mean annual increment.
		Square ft.	*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
25 years	2,430	163	31	2,700	108	108
30 years	1,840	183	38	3,700	200	123
35 years	1,250	195	45	4,850	230	139
40 years	870	212	52	5,800	190	145
45 years	640	221	59	6,600	160	147
50 years	510	228	65	7,300	140	146
55 years	430	233	71	7,925	125	144
60 years	380	236	76	8,500	115	142
65 years	340	238	80	9,000	100	138
70 years	310	241	84	9,450	90	135
75 years	280	244	87	9,900	90	132
80 years	260	247	89	10,300	80	129
85 years	240	250	91	10,650	70	125
90 years	220	253	93	11,000	70	122

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Pine, white— Yield per acre.

SOUTHERN NEW HAMPSHIRE.

[Data gathered by L. Margolin for Graded Mill Tallies, 1906.]

Age.	Quality III.					
	Number of trees.	Basal area.	Mean height.	Volume.	Current annual increment.	Mean annual increment.
		Square ft.	*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
25 years	2,430	150	28	2,300	.....	92
30 years	1,840	165	35	3,033	146	101
35 years	1,250	176	42	3,850	163	110
40 years	870	185	48	4,567	143	114
45 years	640	191	54	5,200	126	116
50 years	510	197	60	5,833	126	116
55 years	430	201	66	6,375	108	116
60 years	380	205	71	6,900	105	115
65 years	340	208	75	7,367	93	113
70 years	310	211	79	7,817	90	112
75 years	280	213	83	8,233	83	110
80 years	260	216	85	8,600	73	107
85 years	240	218	88	8,917	63	105
90 years	220	221	89	9,233	63	103

Pine, white (second growth)— Yield per acre.

SOUTHERN NEW HAMPSHIRE.

[Data gathered by L. Margolin for Graded Mill Tallies, 1906.]

Age.	Quality I.	Quality II.	Quality III
	Volume.	Volume.	Volume.
	Board feet.	*Board feet.*	*Board feet.*
20 years	4,600	3,150	1,700
25 years	8,400	5,900	3,450
30 years	15,100	10,800	6,550
35 years	24,950	18,050	11,200
40 years	33,550	25,000	16,450
45 years	40,750	31,450	22,150
50 years	47,450	37,800	27,650
55 years	52,350	42,550	32,750
60 years	57,300	47,400	37,500
65 years	61,850	51,850	41,850
70 years	65,900	55,800	45,700
75 years	69,750	59,500	49,250
80 years	73,300	62,850	52,400
85 years	76,700	66,000	55,300
90 years	80,050	69,000	57,950

NOTE.—Volume in board feet is round-edged box board material.

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Pine, white—Yield per acre—Of thinnings.

SOUTHERN NEW HAMPSHIRE.

[Data gathered by L. Margolin for Graded Mill Tallies, 1906.]

Age.	Quality I.			Quality II.			Quality III.		
	Total thinning per acre.		Trees under 5 inches in diameter breast-high.	Total thinning per acre.		Trees under 5 inches in diameter breast-high.	Total thinning per acre.		Trees under 5 inches in diameter breast-high.
	Cubic ft.	*Board ft.*	*Cubic ft.*	*Cubic ft.*	*Board ft.*	*Cubic ft.*	*Cubic ft.*	*Board ft.*	*Cubic ft.*
25 years	1,350	2,000	830	900	750	750	600	.....	600
30 years	1,730	4,500	660	1,380	3,300	600	1,090	2,200	500
35 years	1,980	6,800	480	1,680	5,600	450	1,440	4,300	400
40 years	2,120	8,700	270	1,900	7,500	300	1,640	5,800	300
45 years	2,240	10,100	60	2,040	8,900	150	1,750	6,900	200
50 years	2,280	11,200	.....	2,100	9,900	.....	1,800	7,600	80
55 years	2,280	12,000	.....	2,100	10,400	.....	1,780	8,100	.....
60 years	2,260	12,300	.....	2,000	10,600	.....	1,700	8,300	.....
65 years	2,200	12,300	.....	1,850	10,300	.....	1,590	8,200	.....
70 years	2,100	11,900	.....	1,630	9,500	.....	1,420	7,800	.....
75 years	1,950	11,100	.....	1,300	8,000	.....	1,200	6,900	.....
80 years	1,700	9,500	.....	860	5,000	.....	920	5,600	.....
85 years	.....	.....	.....	200	1,200	.....	650	4,000	.....
90 years	.....	.....	.....	.....	.....	.....	370	2,300	.....

NOTE.—Volume in board feet is round-edged box board material.

Poplar, yellow—Yield per acre.

FAIRFAX COUNTY, VA.

[Data gathered by W. W. Ashe for Second Growth Yellow Poplar Study, 1907.]

Age.	Qualities I and II.			Quality I.		Quality II.	
	Number of trees per acre.[a]			Yield.		Yield.	
	Under 5 inches.	5 inches and over.	Total.	Trees 5 inches and over.	Trees 7 inches and over (Scribner).	Trees 5 inches and over.	Trees 7 inches and over (Scribner).
				Cubic feet.	*Board feet.*	*Cubic feet.*	*Board feet.*
10 years	930	20	950	50	.....	.....	.....
15 years	640	160	800	1,000	500	525	.....
20 years	310	250	560	2,450	3,000	1,250	1,350
25 years	100	285	385	3,425	8,475	2,065	3,250
30 years	65	290	355	4,050	11,750	2,750	5,800
35 years	55	275	330	4,500	13,750	3,250	8,000
40 years	55	255	810	4,875	15,325	3,625	9,650
45 years	45	235	280	5,175	16,825	3,900	10,900
50 years	35	210	245	5,450	18,300	4,100	11,900

[a] No regular difference could be seen in number of trees per acre between Qualities I and II.

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Total tree basal area on best tracts of virgin forest land in different regions.

[Secured from stand tables made by the Forest Service.]

Forest description.	Locality.	Basal area per acre.
		Square ft.
Virgin spruce forest {60 per cent hard woods, 37 per cent spruce}	Adirondacks, N. Y.	136
Virgin spruce forest	Maine	90
Do	do	108
Do	do	111
Virgin spruce forest (44 per cent spruce)	New York	100
Virgin spruce hard wood (25 per cent spruce)	do	100
Virgin spruce swamp (43 per cent spruce)	do	75
Virgin spruce (64 per cent spruce)	New Hampshire	140
Virgin spruce hard wood	do	130
Virgin white pine	Michigan	128
Virgin red pine	do	121
Virgin white pine	Minnesota	200
Average northern forests (75–200 square feet)		120
Second growth hard wood coppice (40 years old)	Pennsylvania	[a] 78
Virgin hard wood	Kentucky	93
Culled hard wood	do	[a] 50
"Barrens" timber	Cecil County, Md.	92
"Shore" timber	do	126
"Virgin hard woods"	North Carolina	122
Hemlock hard woods	do	150
Virgin cove hard woods	Tennessee	[b] 133
Average, central hard wood virgin forests (90–150 square feet)		117
Second growth hard wood bottom (60 to 70 years old, 47 per cent red gum).	South Carolina	164
Swamp (cypress, 21 per cent; gum, 72 per cent)	do	113
Longleaf pine (34 per cent) land	do	60
Longleaf pine land	Alabama	63
Longleaf pine land (creek)	do	32
Longleaf pine land	do	53
Loblolly pine land (thicket) (150 years old)	Texas	78
Loblolly pine land (prairie) (over 60 years old)	do	142
Average, southern pine forests (30–120 square feet)		70
Western yellow pine	Arizona	28
Do	do	31
Western yellow pine (50 per cent)	Eastern Washington	55
Lodgepole pine	Montana	130
Lodgepole pine and Engelmann spruce	do	85
Do	do	132
Average, Rocky Mountain forests (30–130 square feet)		80
Douglas fir	Washington	[c] 230
Douglas fir, western yellow pine, and sugar pine	Oregon	188
Western yellow pine, incense cedar, and sugar pine	Madera County, Cal.	[d] 227
Do	Butte County, Cal.	[d] 242
Western yellow pine and sugar pine	Eldorado County, Cal.	215
Do	McCloud, Cal.	200
Average, Pacific coast forests (190–240 square feet)		220
Redwood	California	{700 1,000}

[a] Not included in average. [b] 6,000 feet b. m. [c] 24,000 feet b. m. [d] Altitude, 4,000 feet.

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Total basal area and mean annual increment of normal forests from yield tables for European-managed forests and American-unmanaged forests (sample plots of normal stand).

Species.	Locality.	Quality and remarks.	Age.	Per acre.		
				Trees.	Basal area.	Mean annual increment.
			Years.	*Number.*	*Square ft.*	*Cubic ft.*
Beech	Germany	Quality I	80	269	168	86
Do	do	Quality I	120	157	192	87
Spruce	do	Quality I	80	308	261	165
Do	do	Quality I	120	189	288	132
Scotch pine	do	Quality I	80	218	197	85
Do	do	Quality I	120	154	212	70
Silver fir	do	Quality I	80	325	347	161
White pine	New Hampshire	Quality I	80	260	263	150
		Quality II			247	132
Paper birch	Maine	Quality II. Density 75 per cent.	60	300	94	47
Do	do	Quality I. Density 83 per cent.	60	260	120	65
Loblolly pine	Eastern Texas		40	150	126	93
Yellow poplar (second growth).	Virginia	Quality II	60	165	129	76
Hard woods (second growth).	Southern Appalachians.	Average ridge and slope.	70	180	140	34

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METHODS OF INCREASING FOREST PRODUCTIVITY.

By E. E. Carter,
United States Forest Service.

INTRODUCTION.

Proper management of any forest necessitates complete protection from fire, and a market in which wood material of both large and small sizes is salable at a price sufficient to make the practice of intensive forestry profitable. Both of these conditions will prevail in this country in the future. Therefore, they are assumed in this paper.

Productiveness will be treated as the equivalent of growth. In a properly managed forest the cut is equal to the growth or increase in wood material, and therefore for such a forest productiveness means both growth and the amount cut. In our forests the cut exceeds the present growth, or production of wood by the forest, for we are now cutting annually the growth of many past years. In the near future the cut can not increase except as the increase in growth or productiveness of our forests makes it possible.

Increase in both the quantity and the quality of the product of our forests can be secured through proper management. The increase in quantity will result from an increased area of absolute forest land being made producing forest, and from having this area stocked with those species of trees which produce in the shortest time the classes of material desired in this country. The increase in quality will result from managing these stands so that material of desirable size and shape is produced.

QUANTITY OF PRODUCTION.

INCREASED AREA.

PRODUCTION FROM FORESTS NOW VIRGIN OR MATURE.

When settlement began the forests of the United States were not producing forests, nor are the yet uncut and unburned areas producing to-day. There are growing trees in all our mature or virgin forests, but their growth is merely enough to offset loss from natural causes, such as decay, windfall, lightning, and insects. The forest has produced and is now merely keeping the amount of its crop at the point reached years, perhaps centuries, ago. It is forest ready for cutting and can be made producing forest only by cutting in a way that will encourage a new crop to grow.

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Ultimately the present virgin or mature forests will be cut over, and the land used either for agricultural crops or for new crops of timber. Under proper management the present condition of unproductiveness will never occur again, for the timber crop on any area kept in forest will be cut as soon as, and usually before, it has stopped increasing. The ideal toward which the forester aims in securing this result may be illustrated by assuming that 100 years are required for a timber crop to become mature; that an area of 100,000 acres is to be handled as one forest, and that each cutting is followed immediately by reproduction. The forest would then be divided into a series of one hundred stands, each of 1,000 acres, differing in age by one year, from the yearling trees up to the century old mature timber. Each year the stand which has reached the century mark would be cut, and the crop from that stand of 1,000 acres would be equivalent to the growth for that year on the whole tract of 100,000 acres. Thus the whole forest would be continuously productive.

In our virgin forests it is as if each stand on reaching the age of 100 years had remained stationary until the whole forest is composed of mature timber. There is no increase in the amount of timber on the ground and consequently no productiveness.

It is unnecessary that this virgin forest be cut clean in order to become productive. The removal of the mature timber will give an opportunity for the younger trees already present to grow to maturity, and thus the area will be made productive. In fact, after the cutting of the mature trees which have overtopped them, the young trees will respond to the increase of light, and, in more dry portions of the country, to the increased soil moisture available for them, and they will make more rapid growth than if the forest had been left untouched. Where clean cutting and the establishment of the new crop by artificial means are practicable, or the cutting of mature timber and the leaving of a sufficient number of young trees to insure a full second crop, the area so cut over becomes once more productive.

There are approximately 188,000,000 acres of mature forest, exclusive of woodland, in the United States, not one acre of which can be classed as producing forest. Some of this land is more valuable for agricultural crops than for growing timber, and will be put under cultivation as soon as cleared. A conservative estimate, however, is that 135,000,000 acres of the present virgin or mature forest are more valuable for growing forest crops than for any other purpose, and will become productive forest land.

PRODUCTION FROM WASTE LANDS.

There is in the United States another class of lands which has no productiveness at present. Worn out agricultural soils, cut and burned areas which are not restocking, and sand dunes, are examples of what are commonly called "waste lands." Experiments have shown that some of these areas need only protection from fire to become productive. Any of them can be artificially stocked with forest trees, and so made productive, for forests can grow on soils too poor for successful agriculture, and, as a rule, should be allowed to grow only on such soils. Also, it is extremely probable that future experiments will show it practicable to grow forests on land too dry, too acid, or too alkaline for farming.

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There are 81,000,000 acres of forest land, exclusive of woodland, which have been cut or burned over, but are not restocking. Possibly 10,000,000 acres can be used for agriculture, but additions from worn out agricultural soils, sand dunes, and other sources give a total of at least 90,000,000 acres of waste lands in the United States, all of which can be made productive by artificial stocking with forest trees, or in some cases by merely giving protection from fire.

In making this estimate no consideration has been given to the increasingly large areas of plantations on soils which might be classed as agricultural, but which are devoted to tree production for the sake of windbreaks, or farm woodlots. These are not waste lands, but may be classed with them, for they are areas which are not now, but in the future will be, productive forest. They are, however, not considered, in order to make the estimate of 90,000,000 acres the more conservative.

INCREASED AREA FROM SECURING FULLY STOCKED STANDS.

In the United States it is the exceptional forest, even among those which are now producing, which is fully utilizing the area on which it occurs. Lack of care at the time of lumbering and failure to take steps to secure a fully stocked stand give openings in the forest, some of which are occupied by underbrush.

Many of our forests are naturally somewhat open on account of the inability of certain species to endure the slightest crowding by their neighbors. For example, in an old forest of longleaf pine the crowns of the trees cover hardly more than half of the ground, and yet the stand may be fully stocked in the sense that all the trees of that species which can be produced on the area are already growing on it. It is not such lack of density that is considered here, but rather the failure to have the ground occupied as fully as is possible by the species best adapted to the site conditions.

The examples of this lack of density can be found in every part of the country. On the Pacific coast cut-over areas are frequently stocked with a very scattering stand of trees with a dense cover of chaparral or other brush over most of the ground. This underbrush is not only unproductive, but prevents the forest from becoming more dense, since seedlings are unable to start under its shade or to secure the moisture necessary for their existence in competition with the roots of the brush. In the Rocky Mountain region the yellow-pine forests are almost invariably badly understocked as a result of fire or excessive grazing. In eastern Pennsylvania and other middle Atlantic States there are large areas bearing only a very scattering stand of pitch pine and hard woods, while most of the ground is covered with scrub oak and other worthless underbrush.

There are some exceptions to this lack of density. For instance, there are areas of second growth white pine in New England, second growth Douglas fir in the Northwest, or redwood sprouts in California which are fully stocked. It has been shown, however, that taking averages by forest regions, our second-growth lands have only 30 to 51 per cent of the stand necessary to make a fully stocked forest. It is, therefore, safe to assume that at least 80 per cent of our present producing forest of 225,000,000 acres is stocked with only 50 per cent of the trees which should be growing in it, or that our present growing forest could grow on 145,000,000 acres.

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Under proper management all of this land will be fully stocked. The vacancies in our present producing forests are, therefore, equivalent to an area of over 80,000,000 acres. If the 135,000,000 acres of unproductive virgin or mature forest and the 90,000,000 acres of unproductive waste lands are added, the total possible increase in area of productive forests is found to be 305,000,000 acres.

INCREASED GROWTH.

RETENTION OF FAST-GROWING SPECIES ONLY.

Some of our native species are among the fastest growing found in the Temperate Zone. White pine and Douglas fir are being used to a large extent in European forests because their growth equals or exceeds that of any native European species. However, there are about 500 species of trees native to the United States, many of which are very slow growing or fail to attain useful size. The wood of others is of very little use on account of poor mechanical properties. It is certain that under proper management these "weed trees and runts," as Doctor Fernow calls them, will be practically eliminated from our forests. Probably not over 70 species will be purposely retained on account of their value for producing wood material.[a]

In determining what trees shall remain in our forests, one of the chief considerations will be the rate of growth, and this will be considered by stands rather than by individual trees.

If production is considered on the basis of weight rather than volume, for the present, it is obvious that stands of species, which fully utilize the influences which cause tree growth, will have a larger production than those which only partially utilize these same resources. Consequently on any site a species, or mixture of species, which forms a complete cover and thus utilizes the sunlight more completely will have a greater production than a species or mixture which, from the inability of the trees to stand shading, must have open spaces between the trees which allows a portion of the sunlight to reach the ground. For example, a forest of spruce will have a far greater weight production than a forest of paper birch, for the former shades the ground so completely that there is usually no underbrush or grass, and the energy from the sun's heat and light is almost completely utilized by the spruce, while with the paper birch only a portion of the sunlight energy is used by the trees, and the remainder reaches the ground where it enables the cover of grass or brush to exist. In his "Economics of Forestry," page 158, Doctor Fernow says: "The intensity of utilization of the light is the important factor in weight production, and ceteris paribus, in volume production." Other characteristics of trees, such as the ability to extract moisture from relatively dry soils, affect the weight production similarly.

Volume production and weight production are not interchangeable, for the specific gravities of our native woods vary greatly, but there are many opportunities for replacing species which grow very slowly in weight and volume, as a result of incomplete utilization of natural resources, or which do not attain useful sizes and form, with species

[a] Fernow, Econ. of Forestry, p. 169.

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which will grow more rapidly to usable dimensions and form. For example, there are many areas in the eastern United States at present covered with red cedar, a relatively slow growing tree. The cedar could be replaced nearly everywhere by some faster growing species, such as red oak or tulip poplar for the better soils, and white pine or Norway spruce for the poorer. Another illustration of increased yield both in weight and volume is the replacement of gray birch on worn-out fields and pastures in New England by white pine—a process not infrequently occurring naturally. Still another illustration can be made by considering the replacement of hemlock by growing pure stands of white pine, although hemlock probably utilizes the light resources of any site better than white pine, the wood production is low in volume,[a] and its mechanical properties are such that the wood can be used for no purpose for which the more rapidly growing white pine is not suitable. With both gray birch and hemlock the shape and size of the tree render it less valuable than the white pine.

This replacement of species by those which grow more rapidly, and the elimination of "weed trees and runts" will be a very long process, and it will be impossible on account of the need for heavy, dense woods to have all of our forests contain only the most rapidly growing species. For example, cottonwood is one of the most rapid growing of our native species, if it is not the leader in volume production. However, white oak, which grows much more slowly in volume but as fast or faster in weight, will be retained on many soils on which cottonwood could grow, because there will always be a demand for wood of the strength and of the mechanical properties which white oak can alone supply.

Furthermore, the wide differences in site conditions in this country will render it necessary to retain some of our relatively slow-growing species, since they are the only ones which can thrive in certain localities. For example, it will probably be impossible to replace our western yellow pine throughout a large part of its range with any faster growing species, for at present no faster growing species is known which will thrive on most sites now occupied by western yellow pine. Similar conditions exist in Europe, as may be shown by quoting from European yield tables for Norway spruce, beech, and Scotch pine on Quality I sites. These show that at 100 years of age the yield of spruce will be 14,248 cubic feet per acre, for beech 8,860 feet per acre, and for Scotch pine 7,760 feet per acre. Although the yield for spruce is nearly double that for Scotch pine, large areas are occupied with the latter species because the site is not suited for growing spruce, but is better suited for Scotch pine than for any other species.

As European foresters have taken some of our species to secure increased growth in their forests, so it will be possible in some instances to increase the yield of our forests by introducing exotics. Norway spruce makes a faster growth than the red spruce of Maine and the Adirondacks, and is now being used in plantations where fire or reckless cutting have made it necessary to replace a spruce stand. The wonderful growth both in weight and volume of eucalyptus in California indicates that this tree is capable of utilizing favorable site

[a] The specific gravities of white pine and hemlock are, relatively, as 4 to 5.

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factors to a degree far greater than any of our native species, and only its inability to stand frost will prevent its being used to replace our native species over large areas. Unfortunately, its inability to stand low temperatures will result in its being confined almost wholly to areas which are not now forested.

INCREASED PRODUCTION OF MIXED STANDS.

The differences between species in their ability to endure shade make it possible, in some instances where soil conditions admit, to grow trees of shade-enduring species under or with species which only partially utilize the sunlight. The method is analogous to the growing of agricultural crops under fruit trees in orchards. To make this possible, it is necessary that the intolerant or light-demanding species be started before the trees of shade-enduring species, or that the intolerant species grow much faster in height. Natural examples of this condition are numerous. On the Pacific coast there is almost always a heavy growth of western hemlock and red cedar under stands of Douglas fir. In the Rocky Mountains Engelmann spruce and white fir are frequently found growing under lodgepole pine when the stands of the latter species are no denser than they should be to secure good growth. In the hardwood region beech and maple are frequently found growing under stands of more intolerant species, such as tulip poplar. Throughout the country, pines and spruces are found coming up on old burns under the aspen which first occupied the ground. Under natural conditions this situation is only temporary, since intolerant species can not reproduce under the shade of the more tolerant species, and consequently the stand in time comes to be composed wholly of the more tolerant trees. Under careful management, however, cuttings will be so arranged that the land is kept constantly producing its maximum amount. In many cases of deliberate mixing of light-demanding, rapidly growing species with shade-enduring, slow-growing species at the time a crop is started, or the underplanting of the crop of light-demanding species, after they have grown to some size, with some shade-enduring species will be practiced. The total growth on an area so treated will be greater than if either species were grown pure, and incidentally the quality of the product is frequently much improved and soil conditions maintained. An experiment in Silesia showed that a mixture of spruce and pine produced 18 per cent more than if the spruce were grown in a pure stand on the same site, or 28 per cent more than if pine alone had been grown.[a] Similar results may be expected in this country from mixtures of carefully selected species, with increases in total production, although, as has been noted, there are large areas within our forests on which desirable mixtures are growing already.[b]

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[a] Graves, Forest Mensuration, p. 332.

[b] "Only trees which have a fairly full foliage and preserve a good leaf canopy to an advanced age are fit to be raised in pure woods. Species which do not possess these qualities should be mixed with trees of the former kind." Schlich, vol. 1, p. 197 (3d edition).—15.

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INCREASED FERTILITY OF WASTE LANDS AND OPENINGS.

The soil on areas which are covered with forest is constantly improving, largely through the beneficial action of the humus or leaf litter. This action is well known to farmers, especially in the South. Frequently forest growth starts on worn-out fields, grows to maturity, is cut, and the soil on the field found to be sufficiently improved to grow good agricultural crops for a few years. The improvement is the same relatively on soils which are kept under forest continuously. Consequently the producing power of the 90,000,000 acres of waste lands in the United States will improve as successive crops of timber are raised on them. The same is true of many areas of our present producing forests, or even some of our mature and virgin forests, which have in the past been burned and have not been under forest a sufficiently long time to reach their maximum fertility. This gain in producing power is, however, slow and varies greatly with species and localities, consequently no figures for it can be given. It is mentioned merely to emphasize the conservatism of the estimates of the increased productiveness possible in our forests.

POSSIBLE AVERAGE PRODUCTION PER ACRE.

The present growth of fully stocked, growing stands ranges from 30 to 110 cubic feet per acre per annum, with an average of 70 cubic feet for the whole country. The actual production per acre is, however, much less, chiefly owing to the absence of fully stocked stands, and when applied to the small proportion of our forest land which is now productive gives a total annual production of only 6,500,000,000 cubic feet.

The estimated growth per acre of fully stocked stands is already higher than for European countries, for our forests as a whole are in regions extremely favorable for tree growth. As an illustration, it may be stated that on over 75 per cent of our forest area the annual rainfall exceeds 35 inches, and in some localities is over 100 inches. Also, large areas of our forests are already covered with fast-growing species, such as white pine, which, on fair (Quality II) sites, shows a mean annual growth at the age of 60 years of over 140 cubic feet, or double the average for the country.[a]

Any attempt to predict an increase in the growth in cubic feet of fully stocked stands for the country must be purely an estimate. Such an increase is certainly possible, however, and a conservative figure for it is 10 cubic feet per acre, making a total annual production of 80 cubic feet per acre.

TOTAL INCREASE IN QUANTITY POSSIBLE.

The possible increase in growth in cubic feet is equivalent to an annual growth of 80 cubic feet on the 135,000,000 acres of our virgin or mature forests, on the 90,000,000 acres of our waste lands, and on the 80,000,000 acres of land unproductive on account of lack of density in our producing forests. This gives a total of 24,400,000,000 cubic feet. To this must be added an increased growth of 10 cubic feet per acre on

[a] Present Timber Production, Ziegler, in the report of the conservation commission.

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145,000,000 acres (the area on which our present producing forest could be grown), or 1,450,000,000 cubic feet. This makes the total possible increase 25,850,000,000 cubic feet.

QUALITY PRODUCTION.

INCREASED YIELD OF USEFUL MATERIAL.

RETENTION OF NATURALLY WELL-SHAPED AND LARGE GROWING TREES ONLY.

It is not enough that our forests can produce an increased volume of wood. To be truly productive, in the sense of supplying an increased amount of material suitable for use, the wood produced must be of good size and shape. In bringing our forests under proper management not only will slow-growing species be eliminated, but also those which fail to produce stems of a size sufficient to make them capable of use, or of a shape to render possible their use for the objects most desired by the owners of the forests. For example, the redbud of the central hardwood region, although classed as a tree, very rarely attains a size sufficient to make its use possible, and will probably survive only as an ornamental tree in parks and gardens. On the Pacific coast the knobcone pine, even if the poor quality of its wood is disregarded, seldom attains a size sufficient to enable it to be used for saw timber, and consequently it will be especially discriminated against and its reproduction discouraged by foresters. In the Middle West the common catalpa is almost always crooked, and consequently it will be eliminated in time from our forests and replaced, where wood of the same quality is desired, by the straighter growing hardy catalpa. This process of eliminating undesirable species will result in a greater proportion of the total growth of our forests being usable, and will therefore increase the productiveness of our forests.

CONCENTRATION OF GROWTH ON BEST TREES.

Experiments have shown that in a fully stocked stand of any species a definite amount of wood will be grown on a given area each year, or each period of years. Under proper management, the proportion of this growth which will ultimately be used can be greatly increased. If a stand is growing annually at the rate of 80 cubic feet per acre, the proportion of this 80 cubic feet which will ultimately be taken from the forest and used will vary according to whether the wood is placed on stems which have attained or will attain a size suitable for use, or whether it be distributed partly on these stems and partly on trees or branches which will die before reaching a usable size. Therefore, the actual productiveness of the forest can be increased by concentrating as much as possible of the growth on trees which are to remain in the stand until they have attained the most useful size and form.

In this country the benefit of thus concentrating the growth is accentuated by our usual unit of measure of wood products. For practically all saw timber the unit used is the board foot instead of the cubic foot, and timber is sold according to the amount of lumber which can be sawed from the trees. Consequently the larger the tree the greater is the proportion of its actual cubic contents which is paid for and used. It is, therefore, especially desirable to concentrate

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growth on a relatively small number of trees to force them to large size at the expense of many small trees in the stand.

In the management in fully stocked stands there are always many trees which must soon die from the crowding of their neighbors, consequently their increase in volume is practically wasted. In the meantime they are occupying space and securing light and moisture which could be utilized by the trees which are to remain in the stand, and will be so utilized when the weak trees are finally killed. However, in properly managed stands this process is hastened by the removal of the weak trees, and the growth of the better trees is increased correspondingly. This process is known as thinning.

Examples of the need of thinnings are common in the United States. Lodgepole pine in the Rocky Mountains comes up in exceedingly dense stands on old burns. For a time all the trees grow rapidly, but as soon as the crowns of the trees begin to interlace the struggle for existence begins and natural thinning follows. The growth of the large trees is retarded by the lack of space in which to develop their crowns, and growth in diameter especially soon becomes very slow. The ultimate result in such stands when left to themselves is very frequently that at the age of 150 years there are no trees large enough for saw timber, but many trees of small diameter and good height occupy the ground. If from the start the best trees could have been given an opportunity to develop freely as a result of thinning, there would have been fewer trees to the acre, but these trees would have practically the same volume in cubic contents as the present stand, and would be of sufficient size to furnish a large amount of saw timber. Also, if only fuel wood were desired, a larger proportion of the total cubic contents would be of a size suitable for that purpose.

In this country the demand for saw timber makes the size of the trees on a given area the basis for determining whether the stand is ready for cutting, rather than the total volume of the stand. Since this is so, the concentration of the growth of the comparatively large trees shortens the time required to grow a crop of timber. A crop can be grown, harvested, and a new crop started and grown to some size in the same length of time required for the crop to grow without the aid given by thinnings. For a long period of years, therefore, the productiveness of useful material on any forest area is increased.

Natural thinning is always extremely wasteful, since if the stand is left to thin out itself the trees which die are usually left to rot in the woods. Under proper management this material is utilized and forms from 10 to 50 per cent in volume of the total product of any timber crop.

Throughout the United States it is the exception that more than a small percentage of the material cut from our second growth or producing forests is of sufficient size, shape, and quality to render possible its use as saw timber, ties, poles, or any use other than fuel. The cut of cord wood in this country is approximately 100,000,000 cords a year, the greater portion of which is cut from the forests of the eastern United States. These eastern forests are the ones which have been cut over in the past and are now our productive forests. By far the greater part of our saw timber comes from virgin forests. In cubic measurement the cut of cord wood is greater than that cut for any other purpose. This makes it plain that our producing forests are in reality producing only a very small quantity of saw timber as compared with the fuel wood which they supply.

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Proper management by means of thinnings will greatly increase the proportion of large-sized material produced by our forests. Many of our cut-over lands are to-day in practically the same situation as were the forests in parts of Germany at the beginning of the nineteenth century. At that time only 17 per cent of the total amount of timber cut from the forests of Saxony was classed as timber wood. For the period from 1884 to 1893, 79 per cent was timber wood. Similar improvement can be made in our producing forests. At the same time that this increase in the proportion of desirable material was made in Saxony, the annual cut was increased, largely through the use of material removed in thinnings, from 60 cubic feet per acre to 90 cubic feet.

INCREASE IN PROPORTION OF USEFUL MATERIAL POSSIBLE.

If we assume that the total area of our absolute forest land is to be fully stocked with desirable species growing at the rate of 80 cubic feet per annum, the total yield will be 36,000,000,000 cubic feet. Under present conditions, however, an exceedingly conservative estimate would place the proportion of this yield which would be of sufficient size for use as saw timber, ties, poles, or other large-sized products at 25 per cent, or 9,000,000,000 cubic feet. Allowing for waste in logging and milling, this would be equivalent to about 27,000,000,000 board feet. However, by proper care of the forests, the proportion of large-sized material can be raised to at least 50 and possibly to 75 per cent, which would be equivalent to from 54,000,000,000 to 72,000,000,000 board feet per annum; in addition the demand for fuel and other small-sized material would be met by the product of thinnings and the utilization of those parts of the trees which are too small to enable them to be used for saw timber.

SUMMARY.

There are 225,000,000 acres of producing forest in the country. On this area the stand is so open that all the trees could be grown on 145,000,000 acres, which would be producing at the rate of 70 cubic feet per acre annually. By growing only the best species this growth can be increased to 80 cubic feet, an increase of 1,450,000,000 cubic feet.

There is an unutilized area of 80,000,000 acres within our present producing forest. There are 135,000,000 acres of absolute forest land within our virgin or mature forests now unproductive. There are 90,000,000 acres of waste lands which can be made productive by planting or fire protection. All of these areas can be made to produce annually 80 cubic feet per acre, or a total of 24,400,000,000 cubic feet.

The total increase possible in the productiveness of our forests is, therefore, 25,850,000,000 cubic feet.

Only 25 per cent of the yield of our present producing forest is saw timber. It can be made from 50 per cent to 75 per cent saw timber through the concentration of growth on the best trees by thinnings, and the holding of the crop till it reaches good size. This would mean an increase, if all our forest land were productive, from 27,000,000,000 board feet to between 54,000,000,000 and 72,000,000,000 board feet per annum.

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FOREIGN SOURCES OF TIMBER SUPPLY.

By RAPHAEL ZON,
United States Forest Service.

Part I.—THE FOREST RESOURCES OF THE WORLD.

SUMMARY.

The United States ranks second among the nations of the world in the extent of its forests. Russia, including Siberia, has the largest forest area of any country, while Canada ranks third.

The forests of the United States, according to ownership, may be divided roughly as follows:

	Acres.
National forests	100,000,000
State forests	3,000,000
Private and unreserved public forests (unclassified)	442,000,000

The proportion of the forest land owned or controlled by the State is not necessarily an indication of the development of forestry in that State. With only a small percentage of the forest area under its ownership, the Government may exercise great control over the forests of all other owners. Thus, for example, Switzerland, Austria, and France, with only 5 to 12 per cent of the total forests under state ownership, practically manage all the forests within their borders. In the United States there is no national or state supervision over private forests.

The proportion of state-owned forests to total forests in the leading forest countries ranges from 2.2 per cent in Great Britain to 31.9 per cent in Germany, and 84 per cent in Spain. In Germany 66 per cent of the total forest area is under state control.

COMPOSITION.

The coniferous species are of the most value in international trade. Coniferous forests produce a larger percentage of structural timber than hardwood forests. The German tendency is to increase the coniferous producing area at the expense of the hardwood area. To some extent this is also necessary, since hardwoods as a rule require better soil than conifers, and the demands for greater agricultural areas relegate the forests to the poorer soils.

In the United States, as the result of the reckless cutting of coniferous forests and of repeated fires, a conversion into hardwood for-

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ests and brush areas is going on. This is particularly true in New England, the Catskills, and the Lake States.

In the following countries hardwoods predominate—Australia and Oceania, British India, Hungary, Croatia and Slavonia, France, Japan, Spain, Portugal, Italy, British Isles, Holland, Denmark. In the following conifers predominate—Russia, Finland, Canada, United States, Sweden, Norway, Germany, Austria, Switzerland.

The United States is the only country which has such a variety of conditions as to favor over large areas the growth of a great number of both conifers and broadleaf species.

ANNUAL GROWTH.

The following table classifies the principal wood-producing countries according to whether they overcut, cut the equivalent of the annual growth, or undercut their forests:

	Annual growth per acre.	Annual cut per acre.
Countries which overcut.	*Cubic feet.*	*Cubic feet.*
Austria	42.4	60 to 67
Hungary	44.4	30 to 33
Croatia-Slavonia	43.4	30 to 33
Canada	20.0	[a] 17
Norway	11.3	.....
Roumania	[b]	[b]
Spain	[b]	[b]
Portugal	[b]	[b]
Greece	[b]	[b]
Turkey	[b]	[b]
Bulgaria	[b]	[b]
United States	12.0	[a] 42.0
Countries which cut just the annual growth.		
Germany	48.7	48.7
France	37.9	37.9
Switzerland	51.0	51.0
United Kingdom	45.5	45.5
Belgium	58.2?	58.2?
Holland	46.0	46.0
Denmark	.....	.....
Italy	37.3	37.3
Countries which cut less than the growth.		
Russia	31.0	17.0
Finland	19.8	[a] 13.6
Sweden	25.0	19.1
British India	.....	3.0
Japan	.....	35.0
Servia	.....	.....

[a] Plus great fire loss (estimated 170).
[b] No definite figures on these countries, but facts indicate that they are being overcut.
[c] 3.44 cubic feet in state forests (38.7 per cent); 20 cubic feet in private forests (61.3 per cent).

In most countries where at present the forests are being overcut, and they are the countries which still contain virgin timber, the proportion of structural timber to firewood in the cut is much greater than will be the case in second growth. This is true because the forests under the present system of cutting do not improve but deteriorate in quality. This holds true not only of the United States, but also of Canada, Austria, and Norway. With countries like Germany and France the percentage of saw-log timber is gradually increasing through proper methods of management.

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The cut per acre in such countries as Canada, the United States, and Russia does not represent the actual cut per acre, because the figures do not always refer to the actual productive forest area, but include a great deal of unproductive land, such as swamps, burns, etc. If the figures referred only to the productive forest area, if that could be known, the cut per acre would be much higher.

On the whole, the figures of annual cut and growth show a sad state of affairs. Countries which with proper care for their forest resources could continue to be a source of supply of timber to many other countries deficient in wood are, with few exceptions, overcutting their forest and rapidly deteriorating them, and those few countries with large forest resources which do not overcut do it simply because they either lack capital for opening up their forest or natural means of transportation, as rivers, etc. On the other hand, other countries, though they have not enough forests to supply their own needs, continue to deplete what they have.

ANNUAL CONSUMPTION.

The consumption of wood is different in different countries, being dependent on the industrial development, on the presence of coal for fuel, and on substitutes for structural timber. In the following table are brought together the total annual consumption and the consumption per capita in the various countries of the world:

Country.	Total annual consumption.	Consumption per capita.		
		Total.	Timber.	Firewood.
	Cubic feet.	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*
United States	23,000,000,000	260.0	160.0	100.0
Canada	1,111,209,625	192.0	60.0	132.0
Norway	275,000,000	125.0	.....	.....
Sweden	404,000,000	120.0	.....	.....
Finland	237,000,000	91.5	.....	.....
Russian Empire (exclusive of Finland)	6,576,280,000	63.0	25.0	38.0
Austria-Hungary	2,500,000,000	57.0	28.5	28.5
Switzerland	117,000,000	38.0	15.7	22.3
Germany	2,064,122,300	36.6	18.8	17.8
Japan	.....	30.0	.....	.....
France	954,640,000	24.6	6.9	17.7
Denmark	48,826,500	19.8	.....	.....
Belgium	119,604,126	17.7	10.8	6.9
United Kingdom	670,890,000	14.0	12.8	1.3
Holland	67,200,000	13.1	10.3	2.8
Italy	405,548,000	13.0	2.5	10.5
British India	236,611,600	.8+	.....	.....

INTRODUCTION.

Under present economic conditions, there is scarcely a civilized country which economically is entirely independent of all other countries. The life of all nations is now closely interwoven; and even countries like the United States or Russia, which contain within their borders practically all natural resources necessary to make them independent in every respect, are constantly interchanging their products with the rest of the world.

It is therefore impossible to form a clear idea of the possibilities of a country and its future development without taking into account

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the natural resources and the general economic conditions of other countries with which it comes in contact. The highly developed means of transportation makes it often more profitable to obtain certain products from a country which for some reason is best able to produce them than to manufacture them at home, even though it is possible to do so.

A country deprived of certain natural resources may still be prosperous and progressive, because it is able to obtain all that it needs from other countries which have a surplus of the products which it lacks. The British Isles are the most striking example of this. With comparatively limited natural resources and high consumption of timber, grain, and other raw material, England has highly developed industries which enable her to exchange her finished products for the raw materials she needs.[a]

In considering the forest resources of the United States it seems necessary, therefore, to take into account also the forest resources of all other countries in order to determine the extent to which the United States can depend, in case of exhaustion of its own timber, upon the resources of other countries, or to determine the part which it plays and will play in supplying the needs of other countries in forest products.

There is still another reason why it is important in considering the forest resources of the United States to study also the forests and economic conditions of other countries. There is a certain interrelationship between the extent and condition of the natural resources and their use. History clearly shows that in countries with abundant natural resources and sparse population there is no thought of the future, and all energy is directed to the exploitation and reckless use of what nature has abundantly provided. The waste under such conditions is naturally very great and a more economic utilization does not pay. As the population increases and industry grows, the demand for raw material of all kinds increases, and there is a gradual awakening of public opinion to the need of a more careful husbanding of natural resources. Practically all nations have traveled the same road. Some reach this point sooner than others, but every one is inevitably bound to come to the same conclusion. The United States, being younger than European countries and endowed with abundant natural resources, was naturally backward and was until lately lagging somewhat behind. It may therefore be of advantage to this country to seek lessons for our own future guidance in the experience of the older countries which have been benefited by proper care for their forests, waters, and soils.

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[a] This in a general way holds good for forest resources, but with this difference: Forests not only produce timber, but play an important part in the life of every nation by exercising an influence on the water supplies, on agriculture, and the general health of the people. For this reason only a few countries with an insular climate, as England and Holland, may with impunity reduce their forest areas beyond a certain safety limit. Ordinarily a country with a forest area of 20 per cent or less shows to a marked degree bad climatic conditions, with prolonged droughts, frosts, and alternating floods and low water. Portugal with a forest area of only 3½ per cent of the total land area, Spain with 16 per cent, Greece with 13 per cent, Turkey with 20 per cent, Italy with 14 per cent, are good examples of this.

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EUROPEAN COUNTRIES.

The forests of Europe occupy an area of 767,500,000 acres, which is about 31 per cent, or not quite one-third, of the total land area of Europe. The most wooded country is Finland, followed by Bosnia and Herzegovina, and Sweden. The least wooded are Portugal and Great Britain.

In accordance with the proportion of forest to total land area, the countries of Europe may be arranged in the following groups:

	Per cent.
Finland	63
Bosnia and Herzegovina	50
Sweden	47.6
Austria and Russia (exclusive of Finland)	30–39
Bulgaria, Servia, Luxemburg, German Empire, Hungary, Norway, Switzerland, and Turkey	20–29
France, Spain, Belgium, Roumania, and Greece	10–19
Netherlands and Denmark	5–9
Portugal and Great Britain	3–4

The proportion of forests decreases from the north and east of Europe toward the south and west. Russia, Finland, Sweden, and Norway together possess 635,000,000 acres of forest, or 76 per cent of the total forest area of Europe. The following table gives the area now under forest, the percentage of forest area, and the forest area per capita, for most of the European countries:

Extent of forests in European countries.

Country.	Total forest area.	Forest area per capita.	Land area under forest.
	Acres.	*Acres.*	*Per cent.*
European Russia	464,610,600	4.3	36.3
Finland	52,500,000	18.75	54.4
	517,110,600	.....	.....
Austria	23,996,266	.92	26.5
Hungary	18,692,000	1.17	25.7
Croatia and Slavonia	3,769,000	1.64	35.95
Bosnia and Herzegovina	6,380,000	3.99	50.5
	52,837,266	.....	.....
Sweden	49,390,325	9.7	48.6
Germany	34,989,672	.61	25.89
France	24,021,587	.61	18.5
Norway	16,848,000	7.00	21.00
Spain	(?)16,065,000	.88	13.00
Italy	10,115,404	.31	14.28
Bulgaria	7,602,815	2.4	30.00
Roumania	6,367,000	1.08	18.00
British Isles	3,030,000	.10	4.00
Switzerland	2,140,012	.67	20.6
Greece	2,023,380	.83	(a)
Belgium	1,303,736	.2	17.7
Portugal	1,236,000	.23	5.0
Denmark	628,575	.25	6.3
Holland	617,567	.1	7.7
Servia	3,864,774	1.55	32.0
	750,192,313	.....	.....

a Less than 13 per cent.

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NON-EUROPEAN COUNTRIES.

The forests of other countries of the Old and New Worlds, except in a few localities, are little explored, either as to quantity or quality of the timber. In Asia, Russia, British India, and Japan lead in amount of forests. The following table shows the extent of the forest area in the non-European countries in the Old and New Worlds:

Extent of forests in non-European countries.

Country.	Forest area.	Forest area per capita.	Land area under forest.
Asia:	*Acres.*	*Acres.*	*Per cent.*
Asiatic Russia	348,030,000	.....	.....
India (Schlich)	149,000,000	0.6	24.0
Ceylon	6,762,880	.....	.....
Japan	57,718,410	.....	.....
Philippines	49,000,000	.....	.....
Malay States	101,560	.....	.....
Straits Settlements	88,320	.....	.....
Cyprus	448,000	.....	.....
Australasia:			
British Australasia	126,720,000	.....	6.4
Java	4,920,000	.....	.....
Hawaiian Islands	1,224,992	.....	.....
Africa:			
Cape Colony, Natal, Swazeland, and Transvaal	640,502	.....	.....
Mauritius	87,680	.....	.....
Madagascar	25,000,000	.....	19.0
Barbary States	9,526,865	.....	.....
Central Africa	224,000,000	.....	.....
South America (tropic)	528,000,000	.....	.....
West Indies	42,668,800	.....	66.6
North America:			
Canada	799,360,000	.....	38.0
Mexico	25,000,000	1.8	5.1
Alaska	107,000,000	.....	.....
United States	545,000,000	.....	29.0
Total	3,050,298,009	.....	.....

As may be seen from this table, the non-European countries possess a forest area of over 3,000,000,000 acres. This with the 750,000,000 acres of European forests, form an enormous total of almost 4,000,000,000 acres, or 24 per cent of the total land area of the world. If to this we add the forests of China, Korea, South America, and Africa, for which there are no available data, the extent of the forests of the world will be still greater. Unfortunately, all figures for forest areas are more or less approximations. While the figures for the forests of Austria-Hungary, Germany, France, Sweden, Norway, Finland, Belgium, and Switzerland are fairly accurate, the figures for Russian, Canadian, or even our own forests are only approximate, and will eventually need correction as our knowledge of the forest resources increases. The enormous forest areas in Russia, the United States, and Canada include a large proportion of unproductive land, such as swamps, burns, or lands which sooner or later will be taken up by agriculture, and which do not therefore give a true idea of the forest land proper. The figures, also, showing the percentage of forest land give only an approximate picture of the distribution of forests in the country, because the proportion of forests to total land area greatly varies in different parts of the same country.

Under "forest" is usually understood to mean land covered with woody growth of economic importance. In prehistoric times, after

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the Glacial Period and also in the early anthropo-historic times, according to traditions and written documents, forests occupied much larger areas than now. However, there are scientists who hold that some forests—in Europe for instance—were preceded by prairie.

The character of the forest depends upon climate. Forests of cold and moderate regions contain fewer species and are more homogeneous in composition than those in tropical regions. True tropical forests are found in some parts of India and in the basins of the large rivers of South America and Africa. In Java, Borneo, Kongo, and along the Amazon and Oronoco the forests are extremely rich in variety of species.

In the world market the wood of common trees has the greatest economic importance. Pine, spruce, larch, and fir are used for construction purposes; while oak, birch, hickory, etc., are used by wood-working industries. The amount of rare precious woods which are used as articles of international trade is comparatively small.

The different countries of the world may be divided into two groups, according as their wood exports exceed their wood imports, or vice versa.

The countries whose wood exports exceed their imports are: Austria-Hungary, Canada, Sweden, Russia, Finland, the United States of America, Norway, Bosnia-Herzegovina, Roumania, and Japan; the countries whose wood imports exceed their exports are: The United Kingdom, Germany, France, Belgium, Spain, Italy, Holland, Denmark, Switzerland, Australian colonies, British possessions in Africa, China, Greece, West Indies, Bulgaria, and Servia.

This investigation can not be as complete as is desirable because data for many countries are entirely lacking. The facts here given are the best that could be obtained.

In determining the forest resources of European countries it was impossible to obtain any figures which would show the total stand in cubic feet or board measure. In most European forests the cutting of timber is confined either to the annual growth or to a fraction of the annual growth and does not take into consideration the forest capital which produces this growth. The Europeans use the annual growth as the criterion of the present stand.

The forest capital itself, or what we call the present stand, is a constant quantity which is not to be disturbed. With improvement of the forest capital (more fully stocked, faster-growing species, etc.), the annual growth increases and more timber is available for annual cutting.

In this country and Canada, where there are still large areas of mature timber and but little forest management in the strict sense of this word, the present stand in cubic feet or board measure is of special interest, as it shows how much virgin timber is available for cutting and how long it will take to exhaust the supply.

In order to make the results obtained for different countries comparable it was attempted in every case to show the forest area, the annual growth, and annual cut, and from these three factors to make deductions as to the forest resources of the different countries. The topics discussed for each country are as follows: Forest area; distribution of the forest throughout the country; composition and character of the forests; annual consumption, cutting, and growth per acre; and wood prices.

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FOREST RESOURCES OF VARIOUS COUNTRIES.

AUSTRIA-HUNGARY.

Austria-Hungary is the greatest wood-exporting country in the world. It is not so rich in forests, however, as Sweden, although some provinces in Austria are very well wooded indeed. The combined forest area of Austria, Hungary, and Croatia and Slavonia, exclusive of the Provinces of Bosnia and Herzegovina, is 46,440,000 acres, or 30.24 per cent of the total land area. The forests of Austria proper, however, are very different from those of the Hungarian Kingdom, and it will be better to consider the two separately.

AUSTRIA.

FOREST AREA.

Forestry has developed differently in various parts of Austria. In the northwest Provinces, such as Bohemia, Moravia, and Silesia, where the population is denser than in any other part of the Empire, the forests were early taken care of. Being close to Germany, these northwest provinces have followed Germany in the management of their forests, and some of them were almost model forests even as early as 1848. In the mountainous parts of the country, however, the conditions are not favorable for carrying on rational forest management, and there it is far from being what it should be.

DISTRIBUTION.

The distribution of forests is very uneven, as may be seen from the following table:

Forest area by provinces.

Province.	Area.	Province.	Area.
Danube Provinces:	*Acres.*	Northwest Provinces:	*Acres.*
Upper Austria	1,684,241.1	Bohemia	3,725,190.0
Lower Austria	1,007,729.1	Moravia	1,507,531.5
	2,691,970.2	Silesia	430,293.6
			5,663,015.1
Alpine Provinces:			
Salzburg	573,088.5	Northeast Provinces:	
Tyrol	2,730,722.4	Galicia	4,829,265.9
Styria	2,654,118.9	Bukovina	1,106,854.2
Carinthia	1,120,104.9		5,936,120.1
Carlota	1,093,119.3		
	8,189,154.0	Total	23,996,266.2
Sea Provinces:			
Gorowitz and Istria	570,345.3		
Dalmatia	945,661.5		
	1,516,006.8		

COMPOSITION OF FORESTS.

The forests are composed principally of conifers, such as spruce, pine, and fir. The coniferous forests occupy 16,868,700 acres, while the hardwood forests of seedling origin occupy only 3,522,400 acres. The hardwood forests contain oak, maple, beech, birch, locust, and alder.

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CHARACTER OF FORESTS.

The State owns only 10.7 per cent of the forests, or 2,573,000 acres; of this amount, the actual property of the State is only 1,620,000 acres; the rest is bought by the Government with religious funds in its hands and is under its control. Communes own 14.4 per cent of all forests; hereditary and church forests form 13.6 per cent of the forest area, while in the hands of private owners there are 61.3 per cent of the total forest area. Of the latter, 32.4 per cent are in the hands of large owners, and 28.9 per cent in the hands of small owners. The State takes better care of its forests than does any other owner; then come the forests belonging to churches and large owners. The management of communal forests and of those belonging to small owners is poor.

Austria is a good example of the influence of railroads on the exploitation of forests. Thus, before railroads were built in the forested sections of the country, wood was the only fuel, and saw timber was frequently cut for firewood. With the building of railroads, coal was substituted for wood as fuel, and this brought a change in the utilization of the forests. The consumption of firewood by the city of Vienna may be of interest in this connection. Thus, while on an average for the decade 1848–1857, Vienna, then with a much smaller population than now, consumed each year 200,170 cords, of which 77,841 cords were beech wood; for the decade 1888–1897, the annual consumption of wood fell in Vienna to 51,708 cords, of which only 17,563 cords were beech wood. The price of beech firewood during these two periods was $8.76 and $8.01 per cord, respectively, and of softwoods during the same periods was $5.33 and $7.23 per cord, respectively. This decrease in the consumption of firewood and beech wood was due to increase in the consumption of coal and to the fact that beech in the fifties was rarely used for anything but firewood; therefore, the best beech trees were consumed for this purpose. Now, beech finds employment in many uses, and is in great demand in the manufacture of furniture and other products; only the poorest grades are now cut for firewood.

Of the 23,996,266 acres of forest, 20,390,867 acres are managed as high forest, and 3,605,399 acres as coppice and composite forest.

PRESENT STAND AND ANNUAL GROWTH.

The average yearly growth of all the Austrian forests is given as 1,041,234,000 cubic feet, or 42.4 cubic feet per acre. Timber forms 45 per cent of this annual growth. The forests under different management produce different amounts. High forests produce 42.4 cubic feet per acre, of which 45 per cent is timber; composite forests (coppice with standards), 35.3 cubic feet per acre, of which 20 per cent is timber; and coppice, 32.5 cubic feet per acre, of which only 11 per cent is timber. The least growth is in Dalmatia, where of the total forest area only 7.4 per cent is high forest; and the same is true of Gorowitz and Istria, the other sea provinces. In the Tyrol Mountains the forest is scattered and the annual growth is not large, mainly because large areas are devoted to grazing. The total annual growth in the state forests has been estimated lately at 96,767,000 cubic feet. This, divided by the present area of state forests (which

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is 2,573,100 acres), gives 37.5 cubic feet per acre. There are, of course, districts where the annual growth in the state forests is as high as 70 cubic feet per acre. Assuming an average rotation of 150 years, the present stand must be somewhere in the neighborhood of 156,000,000,000 cubic feet, or close to 1,000,000,000,000 board feet, or an amount equal to about one-half of the remaining standing timber in the United States. The figure of the present stand must be considered as only roughly approximate. It is here given simply to compare the present stand of the Austrian forests with that of the United States.

ANNUAL CUT.

According to the latest figures, the annual cut in the Austrian forests varies from 1,413,000,000 to 1,580,000,000 cubic feet of wood, which amounts to from 60 to 67 cubic feet per acre. Since the average growth per acre is estimated at 42.4 cubic feet, this would indicate that the forests are being overcut.

HOME CONSUMPTION.

In order to determine the home consumption of Austria, the exports must be deducted from the total cut. Since, however, the export figures are not given for Austria proper, but for Austria-Hungary as a whole, only the home consumption of the entire empire can be calculated. This will be given when discussing the forest resources of Hungary.

The consumption of wood grows every year—not for firewood, as previously, but in the form of ties for railroads and timber for the construction of railroad stations, cars, etc. The consumption for railroads alone is estimated to be over 35,000,000 cubic feet each year. The paper and pulp factories now demand constantly increasing amounts of timber.

WOOD PRICES.

In upper and lower Austria, Styria, and Silesia the following prices per cubic foot prevail; the prices are per cubic foot at the place of cutting in the woods, but include the cost of transportation to the point of shipment along the road:

Average price of soft woods (in logs) per cubic foot.

	Cents.
1848	2.35
1870	4.7
1897	6.33

Average price of cord wood per cord.

	1848.	1870.	1897.
Hard woods	$1.90	$3.27	$4.63
Soft woods	1.42	2.42	3.41

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In Bohemia and Moravia the following average prices prevail for timber per cubic foot and for firewood per cord:

	1848.	1870.	1897.
Timber:			
Hard woods (in logs)	$0.058	$0.087	$0.115
Soft woods (in logs)	.034	.054	.08
Firewood:			
Hard woods	2.63	4.20	4.91
Soft woods	2.03	3.06	3.98

In Galicia the wood prices per cubic foot were as follows:

	1870.	1897.
Timber:		
Hard woods (in logs)	$0.033	$0.084
Soft woods (in logs)	.028	.109
Firewood:		
Hard woods	1.56	2.92
Soft woods	1.28	4.00

The figures show that the prices of forest products throughout Austria have increased to a great extent in the last fifty years. However, the price of timber has risen much faster than the price of firewood; thus, while timber prices in many localities have trebled, the price of cord wood has only doubled.

In Galicia the prices of saw logs and cord wood have doubled in the twenty-seven years between 1870 and 1897.

HUNGARY.

FOREST AREA AND COMPOSITION.

According to the latest figures available, the forest area of Hungary is 18,692,000 acres. In this is not included the forests of Croatia and Slavonia, which are a part of Hungary. The forests of Croatia and Slavonia include 3,769,000 acres. Since 1885 the forest area of Hungary, with Croatia and Slavonia, has decreased by 54,000 acres. In the northern part (in the Carpathian Mountains) the forests are chiefly hard woods, consisting of beech (1,463,400 acres), oak (1,374,300 acres), pine and spruce (1,776,600 acres), birch (72,900 acres), poplar and willow (27,000 acres), alder, maple, locust (203,000 acres). The hard-wood forests of the Carpathian Mountains are managed as high forest and yield timber of excellent quality.

Hard woods also predominate in the forests of eastern Hungary. The principal species there are beech (5,891,400 acres), spruce and pine (2,421,300 acres), oak (2,772,900 acres), birch (283,500 acres), willow and poplar (64,500 acres), alder, maple, elm, locust, basswood, and larch (70,200 acres).

In the lowlands are found mainly poplar, willow, oak, locust, beech, in all about 580,500 acres. In the forests of the western part, between the rivers Danube and Drave, hardwoods again prevail. Beech occupies 596,700 acres, oak 866,700 acres, spruce and pine

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2,800 acres, willow and poplar 89,800 acres, birch, 86,400 acres, all other species, 72,900 acres.

The areas under different species show clearly that Hungary is principally a hard-wood region, while Austria is principally a coniferous region in which conifers form 82 per cent of the total forest.

Of Hungarian forests 1,182,600 acres are proclaimed as protection forests; 272,100 acres are on shifting sand; 16,889,800 acres are on forest land proper, while 4,220,800 acres are on soil which can not be called absolute forest land.

The forests of Croatia and Slavonia, which form the southern part of Hungary, extend between the rivers Drave and Save, and consist chiefly of hard woods. Coniferous forests occupy only 456,300 acres out of 3,779,500 acres of the total forest area.

Following are the areas occupied by the different species for Hungary and Croatia and Slavonia separately and for the Hungarian Kingdom:

Distribution of forests by States and for Kingdom.

Species.	Hungary.	Croatia and Slavonia.	Hungarian Kingdom.
	Acres.	*Acres.*	*Acres.*
Oak forests	5,200,200	828,000	6,029,000
Beech and other hard woods (except oak)	9,247,500	2,484,000	11,758,500
Coniferous forests	4,217,500	456,300	4,673,700
Total			22,461,200

Thus the Kingdom of Hungary has 26.8 per cent of the total forest area under oak, 52.2 per cent under beech and other hard-wood species, 20.8 per cent under conifers, and 0.2 per cent under brush.

The following areas are managed in the Kingdom as high forest: 3,510,000 acres of oak, 8,367,300 acres of other hard woods, 4,649,400 acres of spruce and pine; the rest, 5,934,600 acres, is in composite and coppice forest, of which 25 per cent is simple coppice.

The forests are distributed according to ownership as follows:

Distribution of ownership by States and for Kingdom.

	Hungary.	Croatia and Slavonia.	Hungarian Kingdom.
	Acres.	*Acres.*	*Acres.*
State forest	2,859,000	724,000	3,583,000
Communal forest	3,745,000	394,000	4,139,000
Church forest	1,207,000	92,000	1,299,000
Private and corporation forest	10,922,000	2,570,000	13,492,000

ANNUAL GROWTH AND PRESENT STAND.

Approximate estimates of the annual growth were made in 1882 and 1894; they do not differ essentially. On an average, one acre of forest in Hungary yielded 44.4 cubic feet, and in Croatia and Slavonia 43.4 cubic feet. The annual yield per acre in coniferous forest was estimated at 58.5 cubic feet, that of oak forest 41.5 cubic feet, and

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all other forest 40 cubic feet. Experience in the State taught that the different species yielded the following sorts of wood:

	Saw logs.	Cord wood and wood for charcoal.
	Per cent.	*Per cent.*
Oak	25 to 40	75 to 60
Beech	3 to 15	97 to 85
Conifers	70 to 85	30 to 15

These figures show that conifers yield the largest percentage of saw timber, and for this reason Hungary with its hard-wood forests could not export large quantities of structural timber, which must be secured chiefly from Austria. The total annual growth is given as 1,000,000,000 cubic feet. At an average annual growth of about 44 cubic feet and an average rotation of one hundred and fifty years the present stand of timber in the Hungarian Kingdom would be represented by 150,000,000,000 cubic feet, or 900,000,000,000 board feet, or an amount equal to a little less than half the remaining virgin timber in the United States.

ANNUAL CUT.

There are no figures available for the total cut in all the forests of Hungary proper. In the state forests the annual cut per acre is 30 to 33 cubic feet per acre, which is less than the annual growth.

ANNUAL CONSUMPTION.

There are no figures for the annual consumption in Hungary alone, so it will be considered together with Austria for the entire Empire.

WOOD PRICES.

Timber brings fairly good prices. Thus oak, the most valuable of all timber trees, is sold in southern Hungary on the stump at 6½ to 11 cents per cubic foot; in Slavonia, at from 11 to 17½ cents per cubic foot. The market prices of saw timber vary from 44 to 55 cents per cubic foot, and sometimes go even as high as 77 cents. Coniferous wood does not command as high prices and is sold at 3.4 to 6.7 cents per cubic foot on the stump, while the finished product in the lumber yard brings as high as from 16½ to 44 cents per cubic foot.

The prices per cubic foot vary according to the species and the kind of wood, as may be seen from the table below:

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Prices of timber and cord wood on stump and in yard.

	On stump.	In lumber yard.
LUMBER.	*Cents.*	*Cents.*
Oak	3.8 to 11.2	9.0 to 13.7
Beech	8.7	11.0
Elm and maple	3.7 to 11.2	7.3 to 13.5
Spruce and pine	1.7 to 6.2	3.8 to 8.4
Larch	2.2 to 8.3	5.0 to 10.0
CORD WOOD.		
Oak	$0.60 to $3.20	$2.07 to $4.02
Beech	$1.31 to $2.60	$2.07 to $4.01

In Croatia and Slavonia the stumpage is given as somewhat higher, especially for oak saw logs and oak staves.

BOSNIA AND HERZEGOVINA.

In considering the forest resources of Austria-Hungary one must mention also the two provinces under the control of Austria, Bosnia and Herzegovina.

The forests of Bosnia and Herzegovina occupy 6,380,000 acres, of which 5,016,660 acres are state forests, and the remaining 1,363,500 acres form private property.

In the state forests 3,572,100 acres are high forest and 1,444,500 acres are coppice. The private forests have 351,000 acres of high forest and 1,012,500 acres of coppice.

The annual cut amounts to 7,487,000 cubic feet of coniferous species, 1,413,000 cubic feet of oak, and 9,006,000 cubic feet of beech, besides a large amount of oak bark for tanning. The exploitation of the forests of Bosnia and Herzegovina is just beginning. Twenty years ago they were hardly used at all.

ANNUAL CUT AND CONSUMPTION FOR THE EMPIRE OF AUSTRIA-HUNGARY.

According to the latest data, the annual cut in all of the forests of Austria-Hungary, including Bosnia and Herzegovina, was 2,827,000,000 cubic feet of wood, or 53 cubic feet per acre. Of this cut one-half was sawed into firewood, the other half made into saw logs, at an average price on the stump of 3.5 cents per cubic foot.

The exports for the period between 1895 and 1899 were, on an average, equal to 320,000,000 cubic feet on the stump. Deducting this 320,000,000 cubic feet from the total cut (2,827,000,000 cubic feet), there remains about 2,500,000,000 cubic feet of wood for home consumption. This, with a population of 43,825,000, would give a consumption of 57 cubic feet to each inhabitant. This consumption was distributed roughly somewhat as follows: 530,000,000 cubic feet were sawed into lumber, 40,000,000 cubic feet were used by the railroads, 30,000,000 cubic feet were consumed by pulp and paper mills, and the rest was used by the people as round timber for construction and fuel. These estimates, though crude, give some idea of the consumption.

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CANADA.

FOREST AREA.

The forest area of Canada is estimated as 1,249,000 square miles, or 38 per cent of the total land area of Canada. Not all of this, however, is timber land; only about one-third, or 400,000 square miles, may be taken as covered with merchantable timber, the rest being brush land. According to Mr. Stuart a very large portion of the Dominion forest lands is of little value for commercial purposes. According to his estimates, which are the latest and are authoritative, only one-fifth of the 1,406,200 square miles given by him as more or less wooded area, or 280,000 square miles, can be considered as timber land of commercial value. At an average stand of 2,000 feet b. m. per acre this would give about 360,000,000,000 board feet of mature timber.

According to Mr. George Johnson, the statistical officer of the Dominion of Canada, the area of forests in the different provinces is as follows:

Forest area by provinces.

Provinces.	Area of forest in square miles.	Land area under forest.
		Per cent.
Prince Edward Island	800	40
Nova Scotia	6,500	31
New Brunswick	14,800	53
Ontario	102,100	46
Quebec	116,500	51
Manitoba	25,600	40
British Columbia	285,600	75
Territories	697,100	29
Total	1,249,000	[a]38

[a] Average.

COMPOSITION.

The Canadian forests are stocked with a large number of species, among which the three most important are white pine, found in the southeast part of the Dominion; spruce, occurring over large areas; and Douglas fir, found principally in British Columbia. Besides these there are a large number of others which play a greater or less part in the lumber trade; as, among the hard woods, ash, birch, elm, maple, beech, oak, hickory, etc. The bulk, however, is coniferous timber, as may be inferred from the fact that of the exports 94 per cent are conifers and only 6 per cent hard woods.

The bulk of the forests is found in the eastern and western provinces, the central part of Canada being occupied by large treeless prairies.

The forests of Canada belong chiefly to the provincial governments and to the railroads. In Manitoba and in the Northwestern Territories the forests are the property of the Dominion government and of Indian tribes.

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ANNUAL CUT AND CONSUMPTION.

The total annual cut as given by the census of 1891, amounts to 2,045,073,072 cubic feet, distributed among the different products as follows:

		Quantity.	Cubic feet.
Square timber	tons	865,896	43,294,800
Logs, masts, and spars	pieces	48,852,225	407,101,875
Staves	M	92,260	791,128
Railroad ties and fence poles	pieces	39,048,162	117,144,486
Telegraph poles	do	303,861	3,282,175
Fire, lath, and pulpwood and bark	cords	11,439,541	1,464,061,248
Shingles	M	939,736	9,397,360
Total			2,045,073,072

The exports were estimated at 613,000,000 cubic feet, which left 1,431,551,150 cubic feet for home consumption. This made a per capita consumption of 296.2 cubic feet. For the last eighteen years the cut has increased enormously. Professor Fernow estimates the present cut at about 2,400,000,000 cubic feet of finished material, which represents not less than 3,000,000,000 cubic feet as it grows in the forest, or about 17 cubic feet per acre. If to this be added the enormous loss of timber through fire, a loss estimated by some to be equal to nearly ten times the amount cut, the drain is at present probably greater than their productive powers; their exploitation is at the expense of the forest capital itself. There are no figures showing the growth per acre, but it is probably at best not more than 20 cubic feet. Schlich[a] gives the total cut of wood for the year 1900, as given in the census report of 1901, as 1,211,209,625 cubic feet, of which 503,527,545 cubic feet were in the form of timber and 707,682,080 cubic feet firewood. This figure, however, can not be the complete returns for the total cut because it is much smaller than the amount given by the census of 1891; the cut since then has increased.

TIMBER PRICES.

The following table conveys an idea of the prices for the different kinds of wood derived from various species, based on the data obtained in the year 1900:

[a] Forest Policy in the British Empire, Vol. I of his Manual of Forestry.

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Quantity and value of timber and firewood in 1900.

Class and kind of wood.	Quantity in solid cubic feet.	Value.	Value per cubic foot.
Square, waney, or flat timber:			
Ash	416,308	$43,331.76	$0.104
Birch	1,203,564	147,044.16	.122
Elm	1,354,765	143,020.08	.105
Maple	346,433	35,990.58	.103
Oak	110,219	19,042.04	.172
Pine	2,381,310	445,389.84	.187
All other kinds	5,914,314	605,074.86	.102
Total or average	11,726,913	1,438,861.32	.122
Logs for lumber, etc.:			
Elm	8,224,100	640,421.36	.077
Hickory	165,000	19,153.26	.116
Hemlock	20,077,800	1,094,680.98	.054
Oak	1,042,100	149,605.38	.143
Pine	153,368,100	14,946,604.66	.098
Spruce	104,067,600	7,140,137.04	.068
All other kinds	78,751,600	4,968,582.12	.063
Total or average	365,696,300	28,959,184.80	.079
Miscellaneous timber:			
Wood for pulp	53,442,720	2,107,791.72	.039
Fence posts	33,357,710	564,420.96	.016
Masts and spars	313,880	28,192.86	.089
Piling	2,402,632	228,585.24	.095
Railroad ties	32,607,160	1,367,421.38	.041
Poles for electric wires	2,040,888	202,499.06	.099
Hop and hoop poles	596,074	.....	.....
Staves bolts, and headings	1,343,268	23,177.34	.038
Total or average	126,104,332	4,666,081.56	.037
Total of all timber	503,527,545	35,065,327.68	.069
Total of all firewood	707,682,080	14,141,171.16	.01
Grand total of all wood	1,211,209,625	49,206,498.84	.04
Tanbark	.....	427,203.72	.....
Pot and pearl ashes	.....	18,676.98	.....
		49,652,379.54	

RUSSIA.

FOREST AREA AND DISTRIBUTION.

The forest resources of Russia are enormous. The total forest area has recently been given as 812,640,600 acres, though, as indicated below, this estimate is unquestionably excessive. The proportion of forest to total land area is 15.45 per cent. The forests are very unevenly distributed, however, as is shown by the following table:

Forest area by provinces.

Provinces.	Forest area.	Proportion of forests to total area.
	Acres.	*Per cent.*
Sixty provinces of European Russia	444,711,600	36.31
Caucasus	19,899,000	17.20
Western Siberia	307,530,000	30.39
Eastern Siberia	40,500,000	5.01
Total	812,640,600	25.73

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This table does not include the middle Asiatic provinces, as Transbaikal, Amur, and Sakhalin, which comprise 2,316,000,000 acres, and are practically destitute of forests. The proportion of forest for the provinces which have forests is 25.73 per cent, while the proportion of forest to the total area of the empire, without Finland, is only 15.45 per cent. The table also shows how different is the distribution of forests in various parts of the Russian Empire. Thus, while European Russia has over 36 per cent, the Caucasus has only 17 per cent, and eastern Siberia has but 5 per cent of its area under forest. The forests of European Russia are of course of the greatest value. Even there the distribution is very unequal; the five northern provinces contain practically two-thirds of the total forest area.

COMPOSITION.

The composition of the Russian forests is still very little known. In 1893, out of the 315,900,000 acres of forest in European Russia and Caucasus which were under the administration of the forest department, there was 88 per cent of conifers, 11 per cent of hardwood, and 1 per cent of openings and cuttings which did not come up to forest. In Siberia 71 per cent of the total area was under conifers, 29 per cent under hard woods. Oak occupied 3,284,682 acres, either in the form of pure forests or mixed forests in which oak predominated.

OWNERSHIP.

The State owns 640,188,900 acres, or 87.3 per cent of the total area, and only 172,449,000 acres, or 12.7 per cent, belong to other owners. The distribution of the forests according to ownership, however, varies somewhat in the different regions. Of the 444,711,600 acres in European Russia, more than two-thirds belong to the State and Crown, and only 31 per cent to private owners; in the Caucasus the State owns 13,405,500 acres out of a total area of 19,899,000 acres, or 67.3 per cent; in eastern Siberia the State owns about 76 per cent; in western Siberia the State possesses nearly all of the forests; out of 307,530,000 acres, 303,671,700 acres, or 98.7 per cent, belong to the State. Out of 643,067,100 acres of forest belonging to the State there are, properly speaking, only 341,442,000 acres of true forest land, the rest being either agricultural or swamp land. Therefore the total forest area of Russia should be not 812,640,600, but 510,995,500 acres.

Of the total forest area of European Russia, 1,269,000 acres are declared protective forests and 1,225,800 acres are watershed forests. In a similar way, in the Caucasus 81,000 acres are declared protective and 180,900 acres are watershed forests.

ANNUAL GROWTH AND ANNUAL CUT.

A comparison of the annual growth and annual cut per acre in the Russian forests shows that at present only a fraction of the annual growth is actually used. The reason is that the bulk of the forests is located in regions but poorly developed and with no means of transportation. According to the statement of the Russian administration, only a small part of the annual growth can now be

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used on account of lack of market. The condition in 1898 was as follows:

1. In the state forests of European Russia, over a forest area of 237,500,000 acres, the annual growth was 13.6 cubic feet per acre, of which only 40 per cent, or 5.1 cubic feet per acre could be actually marketed and used.

2. In the state forests of the Caucasus, with 13,250,000 acres of forest, out of a possible yield of 38.4 cubic feet per acre, only 16 per cent, or 6.2 cubic feet per acre, was actually used.

3. In the state forests of western Siberia, with an area of 95,000,000 acres, out of a possible yield of 3.1 cubic feet per acre only 40 per cent, or 1.3 cubic feet, was actually cut and used.

More wood is used in other forests than in those owned by the State, but these amount to only about one-third of the total forest area. In all forests not under control of the Government the cutting is heavier than in those owned by the State. In the following table are given the cut per acre and the total cut in the different kinds of forest:

Annual cut in cubic feet per acre and total cut by ownership.

	Cut per acre.	Total cut.
State forest	5.15	1,249,994,000
Crown forest	10.75	201,267,000
Communal forest	11.15	98,868,000
Peasant forest	18.59	910,405,000
Private forest	37.04	4,554,990,000
Total		7,015,504,000

Thus the annual cut in European Russia is about 7,000,000,000 cubic feet for the productive forest land (412,000,000 acres), or 17 cubic feet per acre. On the other hand, the total annual growth for the same area is estimated at 12,711,000,000 cubic feet, or about 31 cubic feet per acre. In other words, the cutting in these forests is a little more than one-half of what is produced each year.

In the forests of Asiatic Russia the exploitation is practically nil, hardly amounting to 1.3 cubic feet per acre.

CONSUMPTION.

If from the 7,000,000,000 cubic feet annually cut in the forests of European Russia is deducted the annual export of 423,720,000 cubic feet, the remainder is a home consumption of 6,576,280,000 cubic feet. This, with a population of 104,000,000, gives a per capita consumption of 63 cubic feet. Assuming that one-half of the annual growth (12,711,000,000 cubic feet) is saw-log timber, there is produced annually 6,355,500,000 cubic feet of such material. With a home consumption of about 25 cubic feet of saw logs per capita, the total would be 2,600,000,000 cubic feet, which would still leave 3,755,500,000 cubic feet available for export. At present the wood deficit in all European countries together amounts in logs to about 1,412,000,000 cubic feet per annum. This deficit may become three times as large, and still European Russia could appar-

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ently furnish enough timber for the countries which depend on importations for their supply.

WOOD PRICES.

In the yearbooks of the Department of the Treasury for 1898 and 1900 are given stumpage prices. Thus, in 1895, in the remote northern government of Archangels, 1 cubic foot of pine timber on the stump was worth 2.7 cents; in 1898, 3.7 cents; in 1895, spruce was selling for 1.9 cents, and in 1898 for 2.1 cents; pine cord wood was worth on the stump 18 cents per cord. In another northern and remote government, Olonezk, timber on the stump was worth 3.5 cents per cubic foot for pine and 2 cents for spruce. In the government of St. Petersburg the stumpage price was 3.7 cents for pine and 2.2 cents for spruce.

In the central governments the stumpage prices were of course much higher. Thus in the government of Moscow the stumpage price for firewood was given in 1898 as $1.60 per cord for pine wood, $1.21 per cord for spruce, $1.16 per cord for oak, $1.70 per cord for birch wood, and 33 cents for all other species; saw-log timber in the same year was worth 6 cents per cubic foot for pine, 3.7 cents for spruce, 2.5 for all other species. In the government of Petrohovsk firewood was selling for $2.31 per cord for pine on the stump, $2.13 per cord for spruce, $3.23 for oak and birch; saw-log timber was selling for 9.8 cents per cubic foot for pine and spruce and 12.3 cents per cubic foot for oak.

These figures give an idea of the range of prices for timber and firewood in the Russian Empire. Stumpage prices have now reached such a point that further advance is hardly to be expected. There are, of course, many places here and there, remote from means of transportation, where forests are still cheap; but as soon as a railroad is built the price of land, and with it the price of timber, will jump at once.

FINLAND.

FOREST AREA.

Finland, although politically part of the Russian Empire, has had an independent economic development.

The forest area may be given as 52,500,000 acres, or 54.4 per cent of the total land area, and 18¾ acres per capita. The State in all owns or controls 32,117,500 acres, or about 61.2 per cent of all the forest area. The rest, 38.8 per cent, belongs to private owners. The forests extend only to the sixty-ninth degree north latitude. Only a few species, like birch, extend farther north. The forests are composed almost exclusively of pine, spruce, birch, and, to some extent, alder. The most valuable species is, of course, the pine, which is, however, of very slow growth. It takes the pine from eighty to two hundred years to reach sizes suitable for construction, and from one hundred and forty to one hundred and eighty years to make saw logs. The farther north it is, the slower, of course, is its growth. As a rule, the spruce occupies more fertile soil than the pine and reaches its development in a much shorter time.

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ANNUAL GROWTH AND CUT.

The cut in the state forests for 1897 amounted to 25,737,000 cubic feet, or 0.74 cubic foot per acre. In the northern forests the cut per acre was only 0.43 cubic foot, while in the rest of the forests there was cut as much as 3.44 cubic feet per acre. Of the total cut, 7,837,000 cubic feet formed cord wood.

In the 20,382,500 acres of private forest there was cut approximately 343,000,000 cubic feet each year, or about 17 cubic feet per acre.

The annual growth per acre for all the forests in the country can be considered as about 19.8 cubic feet per acre. From these figures it can be seen that while in the state forests the cut is considerably below the annual growth, in private forests the annual growth is only a trifle more than the cut.

CONSUMPTION.

The total cut in both private and state forests may be estimated at between 369,000,000 and 379,000,000 cubic feet each year. The exports amounted to about from 132,000,000 to 142,000,000 cubic feet, which, deducted from the total cut, would leave about 237,000,000 cubic feet for home consumption, or 91.5 cubic feet per inhabitant.

WOOD PRICES.

The statistical yearbooks of Finland give the prices of finished sawed lumber. Below are the prices for the period between 1886 and 1897, per cubic foot of sawed boards:

	Cents.		Cents.
1886	9.5	1893	12.8
1887	11.1	1894	12.8
1888	9.7	1895	12.2
1890	14.7	1896	12.6
1891	11.8	1897	13.4
1892	12.6		

SWEDEN.

FOREST AREA.

Up to 1897 Sweden was in the lead of all countries exporting timber. In 1898, however, the exports began to lag behind those from Austria-Hungary, which at that time began to increase enormously.

The lumber industry of Sweden is a comparatively young branch of industry which has grown up in perhaps the last forty years. The country is very rich in forests, but the bulk of them lies in the north, which on account of lack of roads is not easily accessible. It is only with the building of railroads that the present exploitation of the northern forests became possible. The driving of logs in the little streams of the north offers great difficulties, but still these streams are used extensively for this purpose in the same way as are those of Maine and northern New York.

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The distribution of forests by provinces, the forest area, and the area per capita are shown by the following table:

Forest area and area per capita by provinces.

	Acres.		Per cent of total area under forest.	Forest area per capita in 1898.
	1890.	1898.		
				Acres.
Stockholm	1,011,752.1	1,012,216.5	54.8	2.214
Upsala	697,871.7	692,298.9	54.7	5.562
Sodermanland	691,869.6	715,022.1	46.1	4.32
Ostergotland	1,526,774.4	1,532,152.8	62.2	5.53
Jonkopings	564,129.9	733,549.5	27.9	3.65
Kronobergs	605,915.1	607,999.5	27.6	3.81
Kalmar	882,754.2	1,389,600.9	51.3	6.08
Gotlands	365,261.4	341,188.2	44.3	6.51
Blekinge	281,358.9	280,978.2	39.3	1.92
Kristianstads	486,939.6	507,338.1	33.0	2.32
Malmohus	143,448.3	152,220.6	13.0	.38
Hallands	169,965.0	187,987.5	15.9	1.32
Goteborgs	285,975.9	288,189.9	23.8	.89
Elfsborgs	1,092,833.1	1,328,445.9	45.5	4.75
Skaraborgs	728,546.4	740,545.2	37.1	3.05
Vermlands	3,455,462.7	3,368,970.9	77.7	1.32
Orebro	1,255,362.3	1,276,605.9	62.3	6.62
Vestmanlands	904,502.7	848,650.5	53.1	6.62
Kopparbergs	4,823,784.9	5,133,777.3	73.8	24.09
Gefleborgs	3,556,583.1	3,694,337.1	81.7	16.01
Vesternorrlands	3,926,545.2	4,374,361.8	73.4	19.28
Jemtlands	4,866,169.5	7,259,992.2	61.8	66.34
Vesterbottens	5,414,569.2	5,696,557.2	41.3	40.64
Norrbottens	6,853,885.2	7,227,338.4	29.4	57.59
Total or average	44,592,260.4	49,390,325.1	48.6	9.7

The proportion of forest to total land area, as can be seen, is enormous, being 48.6 per cent. The forest area per capita of population is given as 9.7 acres. This explains why Sweden is capable of carrying on such a large international trade in forest products with the whole world, sending timber even to Australia, Africa, South America, etc. The forest area diminishes from north to south. Its distribution per capita varies in different provinces, in some being as high as 66 acres and in others less than one-half an acre.

In 1890 the state forests comprised 18,058,000 acres; in 1898 the area had increased to 18,641,000 acres. Of this amount the State actually owned 10,063,000 acres, while the remaining 8,578,000 acres were either the joint property of the State and of institutions or were merely under state control. The forest area which is owned jointly by the State and private individuals amounted to 2,295,000 acres. There are more detailed data for the state forests and those under state control than for any other class.

COMPOSITION.

Conifers occupy 80 per cent of the forest area; north of the line from Christiania to Upsala (60° north lat.) is the coniferous region. Birch, aspen, and mountain ash form the uppermost vegetative limit in the northern alpine region. Spruce (*Picea excelsa*) forms the limit of coniferous growth and borders upon the birch region. Pine (*Pinus silvestris*) grows along the rivers. In the central part, pine and spruce occur in pure stands, while along the coast and toward the south they form mixed stands. Oak and beech, in mixture with conifers, are found in the south.

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ANNUAL GROWTH AND CUT.

The following table gives an idea of the cut per acre in the state forests and those under state control, for the period from 1889 to 1898:

Annual cut, in cubic feet, in forests under state control.

Year.	Total cut.	Cut per acre.	Year.	Total cut.	Cut per acre.
1889	44,080,000	4.37	1894	46,196,000	4.15
1890	34,908,000	3.15	1895	46,674,000	4.04
1891	39,143,000	3.55	1896	60,374,000	5.19
1892	42,882 00[illegible]	3.85	1897	67,117,000	5.74
1893	38,647,000	3.48	1898	75,532,000	6.11

As may be seen from these figures, the amount cut per acre grows every year, and it now reaches an average of 6.11 cubic feet per acre. It must be remembered that the state forests are found chiefly in the north, and that of the 8,578,000 acres of state forests in 1890 there were 3,537,000 acres which were swamp land.

The sale of timber in the state forests is either by annual auction sales or otherwise to supply the needs of the local population in fuel, and a small amount of timber for construction, or the timber is sold by contract; the latter method is practiced chiefly in the two most northern provinces.

The average amount of timber, not counting waste, cut each year in all of the forests may be taken as 954,000,000 cubic feet, or 19.1 cubic feet per acre. The annual cut of wood for 1897 was figured roughly as follows: Export of timber (in logs), 246,863,000 cubic feet; export of finished products (except pulp wood), 3,532,000 cubic feet; wood for pulp and paper, 200,845,000 cubic feet; timber for railroads, 50,114,000 cubic feet; and wood for all other purposes, 559,874,000 cubic feet, making a total of 1,061,228,000 cubic feet.

This figure is larger than the one given above (954,000,000 cubic feet) as the annual cut; the difference is due to the fact that in the latter case the amounts were given in the rough, including waste, which in some cases is very great. In the northern parts, where there are no means of transportation, the part of a tree which can not be utilized is often as high as 40 per cent, almost as much as in the United States. In central and southern Sweden, however, the waste does not exceed 5 per cent.

The average annual growth in all the forests is greater than the annual cut per acre. The annual growth has been estimated at 25 cubic feet per acre; therefore the annual cut could be increased to 1,235,500,000 cubic feet without depleting the forests.

CONSUMPTION.

If we add to the amount of timber exported in the form of logs and lumber the amount of pulp wood also, the total exports would amount to 350,000,000 cubic feet. If we deduct this amount from the total annual cut of 954,000,000 cubic feet, the remainder represents a home consumption of 404,000,000 cubic feet, or 120 cubic feet per capita. If we include also the waste involved in the production of the total annual cut, the per capita consumption would probably

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be as high as 140 cubic feet. K. von Scherzer[a] estimated the consumption in Sweden (in the eighties) at 101 cubic feet per inhabitant. Mulhull[b] gives the consumption in Sweden and Norway as 92 cubic feet per inhabitant. Since these estimates were made the home consumption in Sweden has increased considerably, and 120 cubic feet per capita may be considered as near the truth.

WOOD PRICES.

Unfortunately there are no recent figures for stumpage prices of timber or wood. The latest available figures are for the year 1890. The following table gives the prices of timber on the stump for the whole tree and by the cubic foot:

Prices of saw-log timber.

District.	Maximum price of saw-log timber.		Minimum price of saw-log timber.	
	Per whole tree.	Per cubic foot.	Per whole tree.	Per cubic foot.
		Cents.		*Cents.*
Norbotten	$0.39	1.6	$0.24.2	0.9
Vesterbotten	1.39	.....	.52.0	.....
Mellerstra Norrland	1.73 to 1.92	.....	0.39 to .52.0	.....
Gefle-Dala	1.42 to 1.78	.....	.52 to 1.04	.....
Bergsland	1.35	5.27	.54.0	.....
Ostra	1.22 to 1.42	.....	.39 to .52.0	.....
Vestra	.....	2.9	.....	1.72
Smaland	0.52 to 0.78	.....	.....	.....

In the district of Sodra the oak wood was sold on an average for 2.57 cents per cubic foot. In the district of Vestra cord wood was sold from the woods at 2.75 to 2.87 cents per cubic foot. In 1892 average auction prices for different kinds of wood were as follows:

Auction prices of timber in 1892.

Districts and provinces.	Timber in the square, per cubic foot.	Sawed timber, per cubic foot.	Timber for construction, per cubic foot.	Cord wood, per cord.
	Cents.	*Cents.*	*Cents.*	
Norbotten	2.2 to 4.4	1.0 to 2.3	0.4 to 1.7	$0.18 to $0.36
Vesterbotten	3.7	1.1 to 3.6	.....	.34 to .45
Mellerstra-Norrland	5.1 to 7.3	2.2 to 7.2	.7 to 3.4	.....
Gefleborg	.....	2.7 to 8.1	.....	.21 to .93
Kopparberg	.....	2.6 to 4.9	.....	.76
Vermland	.....	2.6 to 3.4	.....	3.58
Orebro	2.6	2.9 to 3.6	2.2 to 3.6	1.77
Vestmanland	.....	2.9	.....	1.47
Upsala	2.2	3.6 to 3.9	2.5 to 4.0	1.10 to 1.83
Stockholm	.....	3.2	2.9	1.96
Ostergotland	2.9	3.7	3.2	.....
Gotland	.....	3.7	3.2	1.96
Skaraborg	2.6 to 3.6	2.6 to 3.6	2.9 to 3.6	1.40 to 4.57
Kalmar	3.6 to 6.0	1.6 to 4.8	4.0	.37 to 3.08
Jonkoping	.....	1.7 to 2.2	1.7	1.85
Kronoberg	.....	1.5	.....	1.36

[a] Das wirtschaftliche Leben der Völker, Leipzig, 1885.
[b] Dictionary of Statistics.

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The lowest prices for wood were, as would be expected, in the north. In a book[a] published for the Paris Exposition the price of export sawed timber of third quality from 1873 to 1898 was as follows: In 1873, 18.1 cents per cubic foot; in 1874 it was 26.8 cents. After this the price declined, until in 1879 it was only 10.5 cents. In 1883 the price again reached 18.5 cents, in 1897 it was 20.5 cents, and in 1899 it was an even 21 cents per cubic foot. In 1899 and 1900 the price was still high, but in 1901 it fell.

The north of Sweden, the so-called Norrland, is where timber is cut for export. In 1892 the export from Norrland formed 85 per cent of the total export from the Kingdom, and in 1898 was 73 per cent of the total export. With a forest area of 49,390,000 acres, of which probably not less than 10,800,000 acres must be deducted for swamp and is not forest land proper, Sweden has exported on an average for the three years between 1897 and 1899 wood valued at $46,604,500, or at about $1 per acre. Such an export must be considered very large.

The bulk of saw logs is delivered to the harbor by water. There is not a single river in Norrland[b] which is not used for log driving.

One of the greatest scourges in Sweden, as in this country, is forest fires: In 1887, 14,580 acres were thus destroyed, and in 1892, 145,800 acres.

NORWAY.

FOREST AREA.

With a total land area of 124,130 square miles, Norway possesses a forest area of 16,848,000 acres, or 21 per cent of the total land area. The bulk of the forests lies in the northeast, where the proportion of forest is 38 per cent; in the north the forest occupies only 6 per cent of the land area, and in the central part 13 per cent. The forest area per capita is 1.25 acres.

OWNERSHIP.

The state forests comprise 6,807,500 acres, or 28.5 per cent of the forest area. Over one-half of this amount is in the northern provinces of Tromsoe and Finmark, and of this only 1,970,000 acres are really productive forest land. Corporation forests occupy 787,700 acres, or 4.6 per cent; of this, 632,500 acres are productive. Private forests comprise 10,393,250 acres, or 66.9 per cent.

COMPOSITION.

Coniferous forests occupy 75 per cent and hard woods 25 per cent of the total forest area. Among the hard woods beech, elm, and oak, especially the pedunculate oak, predominate. However, the hard woods do not play an important part economically. Beech only forms forests south of Christiania, oak on the southern and eastern coasts up to 63° north latitude, and birch extends beyond the Arctic Circle inland as well as along the coast.

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[a] La Suède, son Peuple et son Industrie.

[b] L. Passarge. Schweden; Fahrt in Nordschweden und Lappland, Berlin, 1897.

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The most common of all trees is the pine. It extends beyond the Arctic Circle to 70° north latitude, and forms the most northern forest in existence. It occurs all over the country. Its vertical range is also higher than that of spruce. It ordinarily reaches maturity at 150 years, but in the mountains and in the north at 200 years. The spruce does not extend beyond the Arctic Circle, and occurs on the western coast only scattering or singly. In the South it can be utilized at an age of from 70 to 80 years; in the rest of the country, between 120 and 150 years.

In Norway the growth extends much farther north than in any other country.

ANNUAL CUT, GROWTH, AND CONSUMPTION.

The annual cut is given as 345,000,000 cubic feet, or 20.4 cubic feet per acre. In the forests south of latitude 65° (15 provinces) the annual growth is estimated at 20.5 cubic feet per acre—indeed, in the southwest, at 22.6 cubic feet; west and south of Tondhjem, at 17.9 cubic feet; north of Tondhjem, at 11.3 cubic feet. The actual utilization in this region, however, amounts to 21.5 cubic feet. The convenient access to the western coast, with its deep, sheltered fjords, caused the depletion of the forests in that region. It is estimated that during the last one hundred and fifty years 15,000 acres of private forests have been cleared each year. These figures indicate that the forests of Norway are now being overcut.

One-fifth of the total cut (69,000,000 cubic feet) is exported, and the rest, 276,000,000 cubic feet, remains for home consumption. This, with a population of 2,240,000, gives a consumption of 125 cubic feet per capita.

The peculiarity of the export is that the bulk is in the form of logs and staves and not of sawed lumber. Thus, in 1895 to 1899 the export of sawed lumber formed only 28 per cent of the total. This is in contrast to Sweden, which exports chiefly sawed lumber.

WOOD PRICES.

There are no available statistics regarding wood prices in Norway. They can not, however, be very different from those in Sweden.

The Norwegians realize that at the present cut and export, which in itself amounts to 83 cents per acre, they are cutting not only the annual growth, but the capital itself, and that therefore the forests can not last very long.

BRITISH INDIA.

FOREST AREA.

The total forest area of British East India is not known. The area of state forests under the management of the forest department is nearly 149,000,000 acres. There are extensive areas of private and village forests, but they hardly play an important part in the timber supply of the country. Since the government is owner of all land, except in places where it relinquished its right of ownership to individuals or charitable institutions, the present area of state forests probably includes the greatest part of all forests. The forest area occupies nearly 24 per cent of the total land area, and represents 0.6

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of an acre per inhabitant. The state forests are divided into three classes: Permanent state forests (or reserved forests), protected forests, and unclassed forests.

The reserved forest forms only 9.5 per cent of the total land area. In the following table are given the areas of the different classes of government forests in the various provinces:

Government forests, in square miles, under the control of the forest department June 30, 1903.

Provinces.	Total area.	Reserved.	Protected.	Unclassed.	Total.	Per cent of land area under forest.
Bengal	152,453	6,014	3,567	4,033	13,614	8.9
United provinces of Agra and Oudh	105,165	4,048	30	77	4,155	3.9
Punjab	97,223	2,456	4,909	1,914	9,279	9.5
Burma	162,530	20,039	.....	103,174	123,213	75.8
Central provinces and Berar	104,170	22,672	.....	4	22,676	21.8
Assam	49,961	3,778	.....	18,509	22,287	45.5
Coorg	1,582	410	39	121	570	36.0
Northwest frontier province	13,276	234	.....	.....	234	1.8
Ajmer	2,646	142	.....	6	148	5.6
Baluchistan	9,403	208	.....	.....	208	2.2
Andamans	3,143	156	.....	1,795	1,951	62.1
Totals:						
Bengal Presidency	700,552	60,157	8,545	129,633	198,335	28.3
Madras	144,389	17,923	.....	1,636	19,559	13.5
Bombay	122,883	13,487	1,320	.....	14,807	12.0
	967,824	91,567	9,865	131,269	232,701	24.0
Grand total (acres)	.....	58,602,880	6,313,600	84,012,160	148,928,640	.....

COMPOSITION.

The composition of the Indian forests is entirely different from that of the United States or Europe. The forests are almost exclusively hardwood, although some are evergreen and some deciduous. The evergreen forests are found mainly along the west coast of the peninsula, in coast districts of Burma and Chittagong, and along the foot and lower slopes of the eastern Himalayas. The deciduous forests are found in the central part of the peninsula and of Burma and contain the most valuable timber trees, such as teak, sâl, sandalwood, red sanders, ironwood, padouk, and others. Conifers (pine, firs, and deodar) are found at the higher elevations in the Himalayas.

ANNUAL CUT AND GROWTH.

The total cut for 1905–6 amounted to 239,250,000 cubic feet, of which 171,500,000 cubic feet was in the form of fuel. Besides this, there were also cut 210,000,000 bamboos. If this cut be divided by the total forest area, the cut per acre would be extremely small, 1.6 cubic feet; this figure does not really represent the true cut, however, because it is referred to an enormous forest area, of which only a comparatively small portion is actually utilized. When the cut is referred to a definite area, the cut per acre is much larger—for example, in Bengal, in the year 1899–1900, from an area of 5,707,800 acres there were obtained 7,340,000 cubic feet of saw timber, 34,566,000 cubic feet of firewood, and 21,000,000 cubic feet of bamboo, or, in all, about 11 cubic feet per acre, and, not counting the bamboo, only about

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8 cubic feet per acre. Therefore, to get a better idea of the cut per acre, the total cut should be divided by the area of reserve forests (58,602,800 acres), which would make about 3 cubic feet per acre, not counting bamboo.

There are no figures for the growth per acre. From a study made on sâl, the growth per acre of sâl coppice was estimated to be nearly 30 cubic feet per acre per year. Therefore it is safe to assume that the annual growth in the Indian forests is at present larger than the annual cut.

CONSUMPTION.

The timber exports consist chiefly of teak wood, of which 52,768 tons, or 2,638,400 cubic feet, were exported in the year 1905–6. The exports of all other kinds of wood, principally of bamboo, are insignificant. If this amount be deducted from the total cut and there were no importations, there would be available 236,611,600 cubic feet for a population of nearly 300,000,000 inhabitants, or 0.8 cubic foot per capita. There are, however, some imports of timber from Canada, Sweden, and Austria, which, on an average for the five years between 1895 and 1900, formed one-eighth the value of the total exports. Of course these imports slightly raise the per capita consumption. Still the consumption and cut are very small, and the fact that saw-log timber is needed from other countries indicates the lack of structural timber.

WOOD PRICES.

The chief timber of export is teak, and its price at the point of shipment varies from about 80 to about 85 cents per cubic foot.

ROUMANIA.

FOREST AREA.

The forests of Roumania comprise 6,367,000 acres, of which the State owns 40 per cent, the Crown and communities 8 per cent, and private individuals 52 per cent. The proportion of forest to land is 18 per cent and the area per capita is a trifle over 1 acre (1.08). Of the land classed as state forests (2,712,500 acres), 1,497,000 acres are utilized, 806,250 acres are not utilized, and 407,500 acres are burned.

COMPOSITION.

Thirteen and one-half per cent of the total forest area is occupied by spruce and fir; 20 per cent by beech (also mixed with conifers); 28.3 per cent by beech, oak, and elm in mixture; 31 per cent by pure oak forests; and 7.2 per cent by other hardwood species. The conifers occur chiefly in the Alps and Carpathian Mountains, where their exploitation is very difficult. Only part of the state forests are now being utilized. The insignificant exploitation is due to lack of capital and enterprise. The Government, in order to strengthen the lumber industry, imposed a duty on timber, which increased its price, reduced its importation, and stimulated export. In the future Roumania will undoubtedly play an important part in supplying other countries with timber.

There are no data for the annual growth or consumption. Figures for the annual cut are extremely meager and unreliable.

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JAPAN.

FOREST AREA.

The total forest area of Japan, exclusive of Formosa and the Kurile Islands, is 57,718,410 acres, or 59 per cent of the total area. The forests are more extensive in the northern part and are practically confined to the slopes of the mountains which form the backbone of the islands. The greater part of the forests belong to the State. The following gives the distribution of forests according to ownership:

Distribution of forests by ownership.

	Area in acres.
State forests	32,813,300
Crown forests	5,229,472
Municipal forests	4,286,885
Forests of shrines and temples	419,073
Private forests	14,969,680
Total	57,718,410

The state and crown forests are carefully managed, but the private forests are not in such a high state of perfection. In proportion to population, the forest area is quite different in the various provinces; thus in Hokkaido it is 9 acres per capita; in Aomori and Akita, 3¾ acres; in Kochi, 1 acre; in Hiroshima and Kagoshima, three-fourths of an acre; and in Kumamoto only one-half acre. The northern provinces are still rich in virgin forests.

COMPOSITION.

The forests are divided into four zones: 1. Tropical forest; 2. Subtropical forest; 3. Temperate forest; 4. Frigid forest.

1. The tropical forest zone extends over the whole of Formosa, the southern half of the Soochoo Islands, the Yayemaya, and the Ogasawara Islands. The banyan, sieb, and bamboo are the principal growth.

2. The subtropical forest zone comprises a portion of the Soochoo Islands, the whole of Shikoku and Kyushu, and the part of the main island lying south of 36°.

3. The temperate forest zone extends from the northern half of the main island to the southern part of Hokkaido, between 36° and 43° 5′, where the mean annual temperature ranges from 6° to 13° C.

4. The frigid forest zone occupies those parts of the northern half of Hokkaido and the Kuriles, where the average temperature does not exceed 6° C.

On the whole, the composition of the forests is somewhat as follows:

Conifers, 21 per cent; broadleaf forests, 25 per cent; conifers and broadleaf forests, 45 per cent; and sparsely stocked forests, 9 per cent.

In the state forests, the relative proportions of the different kinds of trees is as follows:

Conifers, 11 per cent; broadleaf forests, 28 per cent; mixed conifer and broadleaf forests, 49 per cent; and sparsely stocked forests or openings, 12 per cent.

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ANNUAL CUT, GROWTH, AND CONSUMPTION.

The annual cut of timber for three successive years (1900 to 1902) was on an average 2,055,059,400 cubic feet, or about 35 cubic feet per acre. If Japan were not an exporting country, as it is now, at an annual cut of 2,055,159,400 cubic feet and a population of 43,760,000 (exclusive of Formosa), the annual consumption per capita would be 47 cubic feet. As a matter of fact, exports exceed imports, but the exact amount in cubic feet is not available. The actual per capita consumption in Japan must therefore be less than 47 cubic feet, and an estimated consumption of 30 cubic feet must be close to the truth.

There are no figures of annual growth per acre for the whole country. From some working plans prepared for the different state forests it appears that stands of *Cryptomerea japonica* may produce as much as 130 cubic feet per acre per year, and those of *Thujopsis dolabrata* 100 cubic feet per year. From the fact that the Japanese manage to get excellent agricultural crops it may be inferred that they also know how to husband their forest resources and will be able to supply all of the needs of the population and their wonderfully progressive industries.

WOOD PRICES.

Below is given a table of wood prices at Tokyo for the different Japanese woods used in construction, mining, etc.

Prices and uses of various Japanese woods.

TIMBER.

Species.	Price at Tokyo.[a]	Used for—
Chamaecyparis obtusa.....cubic foot..	$0.40	House, ship, and bridge construction.
Cryptomeria japonica.....do....	.25	Do.
Picea ajanensis.....do....	.275	House and ship building.
Larix Leptolepis.....do....	.275	Ship and bridge building, telegraph poles, sleepers.
Pinus densiflora.....do....	.15	Piles, etc.
Thuja Sieboldii.....do....	.175 .20	House building, shingles, pulp.
Fraxinus Mandshurica.....do....	.25	House and boat building, ties.
Juglans Sieboldina.....do....	.40	Rifle stocks, furniture, carriages.

BOARDS.

Cryptomeria japonica..square foot..	$0.15	Valuable furniture and ornaments.
Thuja japonica.....do....	.05	Shingles, cabinets, etc.
Zelkowa keaki.....cubic foot..	.90	Ship, carriage, and house building.
Acer palmatum.....do....	.40	Implements, wagons, etc.
Fagus sylvatica var. Sieboldi....do....	.125	Boats, sleepers, foundations.
Quercus acuta.....do....	.35	Carriages, machines, implements.
Quercus crispula.....do....	.25	Fuel and sleepers.
Cinnamomum camphora.....do....	.55	Boats, cabinets, camphor.
Magnolia hypoleuca.....do....	.35	Small articles.

[a] Original values are given in yen. 1 yen equals about $0.50 United States gold.

THE UNITED KINGDOM OF GREAT BRITAIN AND IRELAND.

FOREST AREA.

The forests of the United Kingdom occupy but a small proportion of the total land area. The area of woodlands is estimated at

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3,030,000 acres, or 4 per cent of the total land area. The following table gives the proportion of land used for different purposes:

Utilization of the land.

Countries.	Acres of dry land.	Acres under crops and grass.	Acres of forests.	Acres of mountain and heath land.	Acres of other lands.
England	33,390,991	24,679,966	1,665,741	2,224,624	3,710,660
Wales	4,748,498	2,810,824	181,610	1,270,470	485,564
Scotland	19,066,968	4,897,109	878,765	9,299,378	4,008,646
Isle of Man and Jersey	185,453	124,650	869	29,729	30,205
Ireland	19,322,798	15,230,591	308,023	2,226,867	1,562,317
Total	75,706,668	47,743,200	3,030,008	15,141,068	9,792,392
Percentage	100	63	4	20	13

The area under forest per capita is one-tenth of an acre. The area of woodland is smaller than that of any other European country except Denmark. Crown forests comprise only some 67,000 acres, or 2¼ per cent, which is smaller than in any other European state. There are no communal forests. Of the total forest area, 97¾ per cent, or 2,963,000 acres, is in the hands of large private owners.

ANNUAL CUT, CONSUMPTION, AND GROWTH.

The total cut in the United Kingdom for certain periods amounted to: 1855–59, 125,703,600 cubic feet;[a] 1875–79, 131,353,200 cubic feet; and 1895–99, 138,062,100 cubic feet.

Thus the average cut per acre may be accepted as equal to 45.5 cubic feet per year. Assuming that in England only the annual increment is cut, the annual growth would be equal to the total cut. Mulhull estimated that the annual growth per acre is equal to 60 cubic feet, in which case the total annual growth would be 181,800,000 cubic feet. The United Kingdom not only uses all that is cut, but is impelled to import nearly five times that amount.

The total annual consumption and the per capita consumption for a period of years are given in the following table:

Annual and per capita consumption, in cubic feet, for certain periods.

Period.	Produced at home.	Imported.	Total.	Per capita.
1855–59	125,703,600	84,037,800	209,741,400	27.2
1875–79	131,353,200	329,442,300	460,795,500	12.0
1895–99	138,062,100	533,181,000	671,243,100	14.0

Thus the per capita consumption is 14 cubic feet. Half of the total annual cut is firewood; therefore the consumption of timber is 602,212,000, and of firewood is 69,031,000 cubic feet; or the per capita consumption of timber is 12.8 cubic feet, and of fuel is 1.2 cubic feet.

[a] Berichte über Handlung und Industrie 1900, 598.

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WOOD PRICES.

Since the United Kingdom buys nearly half the total export of all the countries of the world, the wood prices in the English market affect practically the whole world. It will, therefore, be of interest to compare the prices for the different kinds of wood imported for a long period of years. The following average annual import prices are borrowed from the Statistical Abstracts for the United Kingdom (1892–1900), covering a period of twenty-four years.

Prices in cents per cubic foot of imported woods.

Year.	Round and hewn logs.			Sawed lumber.	
	Pine and spruce.	Oak.	Teak.	Pine and spruce.	Staves.
1877	22.6	58.8	109.8	.....	59.7
1878	19.7	55.6	92.8	.....	46.2
1879	17.2	48.7	91.5	.....	45.7
1880	19.5	54.4	114.5	.....	42.9
1881	19.7	56.4	125.6	.....	46.7
1882	20.2	58.2	121.6	25.1	48.9
1883	19.5	57.5	134.4	23.5	42.8
1884	17.4	54.5	137.0	22.1	38.8
1885	16.9	54.1	127.3	21.9	40.8
1886	14.9	53.7	115.1	20.8	38.4
1887	14.0	52.1	98.3	19.8	38.8
1888	15.0	51.1	109.3	21.1	38.7
1889	16.7	54.6	112.8	23.6	38.5
1890	15.4	53.8	106.7	22.2	40.5
1891	14.2	55.6	97.0	20.2	42.8
1892	14.2	55.6	100.9	20.6	41.2
1893	13.2	55.7	97.4	20.2	36.7
1894	12.6	57.0	99.2	20.5	38.7
1895	12.8	54.9	91.4	19.7	38.8
1896	13.4	56.0	100.4	20.8	49.8
1897	13.6	54.3	109.9	22.2	42.4
1898	13.9	53.4	111.2	22.2	43.8
1899	13.7	53.2	114.6	22.8	49.3
1900	14.5	55.9	117.7	26.3	46.9

The lowest price for pine and spruce logs was in 1894. In general, the prices of log timber imported into the United Kingdom were lower in the nineties as compared with the prices that prevailed in the seventies. This may be accounted for by a change in the kind and quantity of logs imported. In the seventies the importations consisted chiefly of large logs, while now the timber imported is generally of smaller size and a great deal of it is for mine timbers and pulp. The prices for logs are comparatively uniform. Teak is used in large quantities for the navy, and its price depends not only on the supply, but also on the demand for it. Lately there has been a great demand for the building of the navy and merchant marine, which has increased the price of teak.

The prices for sawed lumber had fallen greatly by 1895, but since then they have shown a continuous increase. The prices for staves were also low in 1894 and 1895, but lately have shown a tendency to rise.

It is also of interest to compare the prices which different countries have commanded for their timber:

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Comparison of selling prices, in cents per cubic foot, of timber in various countries.

	1896.	1897.	1898.	1899.	1900.
Pine and spruce logs from—					
Russia	15.8	16.3	16.9	17.6	18.6
Sweden	13.3	13.8	13.1	14.3	15.7
Norway	13.8	14.3	15.0	15.0	16.6
Germany	20.2	20.8	21.8	24.0	25.2
France	8.1	8.0	8.2	8.2	8.9
United States	28.6	29.2	29.0	32.6	38.2
Canada	55.0	53.0	50.7	54.3	55.0
Pine and spruce sawed timber from—					
Russia	21.9	24.1	24.1	25.0	29.5
Sweden	21.7	23.8	24.0	24.4	27.4
Norway	24.9	27.0	27.1	27.6	28.8
Germany	23.9	25.2	26.3	27.6	35.0
United States	26.4	26.6	26.8	29.2	34.1
Canada	24.4	24.7	24.5	25.1	28.7

The highest prices for hewed as well as unhewed timber were commanded by Canada and the United States, as these countries supplied the largest logs. The timber from Russia contained a great deal of small logs for mines. That from Sweden and Norway was at the lowest prices because it contained very small logs. France ships to England pulpwood only, and such timber is practically on a par with firewood. For sawed lumber, Germany and America commanded the highest prices.

The following tables are of interest as giving details of timber values:

Stumpage prices, in cents per cubic foot, of timber in the south of England, 1904–1905.[a]

	Price.
Prime clean oak, standing	50
Rougher oak	44
Clean-grown ash	60
Beech, 20 inches in diameter and upward	24 to 32
Elm	24
Good clean willow, suitable for cricket bats	60
Hard woods, small dimensions	12 to 18
Larch	24 to 28
Scotch pine and spruce	8 to 16

[a] W. Stone. From Trans. Roy. Scot. Arb. Soc. 1906, pp. 204–5.

Approximate value, in cents per cubic foot, of timber, 1902.[a]

	Under 15 feet.	15 to 25 feet.	25 to 50 feet.	50 feet upward.
Oak	30	40	50	[b] 60
Ash	24	36	[b] 50	.....
Elm	12	18	[b] 24	.....
Beech	18	24	[b] 36	.....
Larch	.....	18 to 28	.....	.....
Scotch pine	.....	12 to 18	.....	.....
Spruce	.....	8 to 12	.....	.....
Spanish chestnut	.....	[b] 36	.....	.....
Horse-chestnut	.....	[b] 24	.....	.....
Walnut (J. regia)	.....	[b] 50	.....	.....
Lime (Tilia sp.)	.....	[b] 36	.....	.....
Hornbeam (C. betulus)	.....	[b] 50	.....	.....
Sycamore (Acer pseudoplatanus?)	.....	[b] 36	.....	.....
Willow	.....	[b] 30	.....	.....
Plane	.....	[b] 24	.....	.....
Poplar, Italian (black)	.....	[b] 20	.....	.....
Poplar, Lombardy	.....	[b] 6	.....	.....
Birch	.....	[b] 24	.....	.....
Maple	.....	[b] 18	.....	.....
Cherry	.....	[b] 18	.....	.....
Acacia	.....	[b] 24	.....	.....
Box	.....	[b] 60	.....	.....
Holly	.....	[b] 50	.....	.....

[a] From Minutes of Evidence, Departmental Committee, British Forestry, 1903, p. 171.
[b] And upward.

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GERMANY.

FOREST AREA.

According to the latest figures obtained by the census of 1895, the total area now under forest in Germany is 34,989,672 acres. This forms 25.89 per cent of the total land area. The forest area is 0.63 acre per capita. The distribution of the forests in the different States in the German Empire is given in the following table:

Area of forests of German Empire, 1900.

States.	Total area of forests.	Land area under forest.	Area per capita.
	Acres.	*Per cent.*	*Acres.*
Prussia	20,675,335.0	23.7	0.60
East Prussia	1,611,187.5	17.4	0.80
West Prussia	1,386,620.0	21.7	.88
Brandenburg	3,329,170.0	33.4	1.08
Pomerania	1,547,937.5	20.6	1.00
Posen	1,432,135.0	19.8	.75
Silesia	2,904,732.5	28.8	.60
Saxony	1,339,087.5	21.2	.48
Schleswig-Holstein	315,782.5	6.7	.02
Hanover	1,651,495.0	17.2	.62
Westphalia	1,415,700.0	28.0	.45
Hesse-Nassau	1,556,665.0	39.7	.82
Rhineland	2,087,475.0	30.9	.35
Hohenzollern	97,347.5	34.1	1.45
Bavaria	6,166,382.5	32.5	1.00
Upper Bavaria	1,255,190.0	30.0	.95
Lower Bavaria	841,857.5	31.3	1.25
Pfalz	578,367.5	39.0	.70
Oberpfalz	895,660.0	37.1	1.63
Oberfranken	607,395.0	34.7	1.00
Mittelfranken	630,275.0	33.3	.78
Unterfranken	781,317.5	37.2	1.20
Swabia	576,322.5	23.5	.80
Saxony	961,350.0	25.8	.02
Wurttemberg	1,501,037.5	30.8	.70
Baden	1,419,487.5	37.7	.75
Hesse	600,022.5	31.2	.53
Mecklenburg-Schwerin	591,850.0	18.0	.98
Saxe-Weimar	232,720.0	25.8	.65
Mecklenburg-Strelitz	155,562.5	21.2	1.52
Oldenburg	170,852.5	10.6	.43
Brunswick	273,682.5	30.1	.60
Saxe-Meinigen	259,647.5	42.1	1.25
Saxe-Altenburg	89,757.5	27.1	.45
Saxe-Coburg-Gotha	148,940.0	30.1	.65
Anhalt	144,485.0	25.1	.45
Schwarzburg-Sondershausen	66,777.5	31.0	.83
Schwarzburg-Rudolstadt	103,325.0	43.9	1.10
Waldeck	106,987.5	38.2	1.85
Reuss (Elder-line)	28,132.5	35.6	.40
Reuss (Younger-line)	77,995.0	37.8	.55
Schaumburg-Lippe	17,247.5	20.3	.40
Lippe	83,720.0	27.6	.60
Lubeck	10,207.5	13.7	.10
Bremen	120.0	0.2	.....
Hamburg	4,467.0	4.3	.....
Alsace-Lorraine	1,099,580.0	30.3	.65
German Empire	34,989,672.5	25.89	.63

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Of the total area, the state forests comprise 31.9 per cent, crown forests 1.8 per cent, communal forests 16.1 per cent, institutions and associations own 3.7 per cent, and private owners 46.5 per cent. Below is given a detailed table showing the forest areas according to ownership in the different States and Provinces:

Ownership of forests of German Empire, 1900.

State.	Crown forests.	State and shared forests.	Communal forests.	Institutes forests.	Association forests.	Private forests.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Prussia	181,050.0	6,396,172.5	2,759,115.0	244,930.0	591,072.5	10,502,992.5
East Prussia	.....	958,475.0	86,122.5	12,882.5	7,525.0	546,207.5
West Prussia	107.5	839,847.5	59,497.5	3,912.5	3,142.5	480,112.5
Brandenburg	110,862.5	997,242.5	400,967.5	28,622.5	5,857.5	1,785,577.5
Pomerania	21,092.5	483,532.5	135,207.5	16,545.0	1,500.0	890,060.0
Posen	1,880.0	460,652.5	29,575.0	20,612.5	485.0	918,930.0
Silesia	82,780.0	379,660.0	278,610.0	29,200.0	1,960.0	2,223,912.5
Saxony	11,440.0	429,292.5	123,900.0	16,245.0	32,627.5	731,302.5
Schleswig-Holstein	.....	90,737.5	33,807.5	4,582.5	512.5	186,142.5
Hanover	.....	600,557.5	116,842.5	52,432.5	233,485.0	648,177.5
Westphalia	.....	123,495.0	139,255.0	12,582.5	134,357.5	1,006,010.0
Hesse-Nassau	.....	652,842.5	532,320.0	31,320.0	103,187.5	236,995.0
Rhineland	.....	379,862.5	825,030.0	14,402.5	64,257.5	803,922.5
Hohenzollern	.....	.....	47,980.0	1,550.0	2,175.0	45,642.5
Bavaria	4,247.5	2,088,592.5	768,885.0	116,202.5	50,037.5	3,138,417.5
Upper Bavaria	170.0	480,920.0	27,147.5	18,375.0	1,007.5	727,570.0
Lower Bavaria	95.0	162,615.0	6,665.0	10,302.5	145.0	662,035.0
Pfalz	62.5	286,017.5	212,955.0	2,692.5	875.0	75,765.0
Oberpfalz	230.0	298,907.5	21,560.0	19,972.5	455.0	554,535.0
Oberfranken	200.0	234,757.5	28,077.5	8,822.5	5,790.0	329,747.5
Mittelfranken	2,060.0	200,222.5	88,005.0	10,972.5	3,412.5	325,602.5
Unterfranken	10.0	250,237.5	286,952.5	20,597.5	27,772.5	195,747.5
Suabia	1,420.0	174,915.0	97,525.5	24,465.0	10,580.0	267,415.0
Saxony	160.0	434,650.0	57,750.0	25,070.0	1,612.5	442,107.5
Wurttemberg	16,205.0	468,790.0	445,487.5	36,317.5	18,387.5	515,850.0
Baden	20,657.5	240,145.0	639,515.0	47,362.5	5,037.5	466,770.0
Hesse	16,621.0	12,302.5	217,375.0	1,690.0	5,565.0	196,875.0
Mecklenburg-Schwerin	19,107.5	248,547.5	56,662.5	29,797.5	.....	237,735.0
Saxe-Weimar	125.0	110,597.5	35,562.5	3,927.5	3,212.5	79,295.0
Mecklenburg-Strelitz	3,242.5	102,692.5	12,220.0	545.0	.....	36,862.5
Oldenburg	932.5	64,362.5	18,065.0	1,400.0	47.5	86,045.0
Brunswick	.....	200,965.0	4,065.0	632.5	44,692.5	23,327.5
Saxe-Meiningen	260.0	110,147.5	60,807.5	1,950.0	22,985.0	63,497.5
Saxe-Altenburg	28,097.5	15,545.0	1,905.0	2,360.0	1,257.5	40,592.5
Saxe-Coburg-Gotha	8,485.0	86,807.5	18,410.0	915.0	8,910.0	25,412.5
Anhalt	49,080.0	59,557.5	2,942.5	1,760.0	207.5	30,937.5
Schwarzburg-Sondershausen	41,872.5	350.0	8,570.0	625.0	7,155.0	8,205.0
Schwarzburg-Rudolstadt	.....	875.0	11,560.0	1,170.0	2,122.5	39,597.5
Waldeck	.....	887.5	23,007.5	497.5	1,975.0	14,620.0
Reuss (elder line)	10,852.5	.....	300.0	680.0	.....	16,300.0
Reuss (younger line)	41,250.0	35.0	2,565.0	1,712.5	12.5	32,420.0
Schaumburg-Lippe	16,207.5	.....	2.5	10.0	.....	1,027.5
Lippe	35,205.5	.....	9,142.5	312.5	1,245.0	35,000.0
Lubeck	.....	.....	12.5	1,362.5	.....	1,507.5
Bremen	.....	.....	.....	.....	.....	120.0
Hamburg	.....	.....	282.5	22.5	.....	1,515.0
Alsace-Lorraine	.....	.....	491,015.0	6,285.0	.....	221,382.5
German Empire	643,255.0	11,149,707.5	5,645,225.0	527,537.5	765,535.0	16,258,412.5

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Ownership of forests of German Empire, 1900—Continued.

State.	Crown forests.	State forests.	Communal forests.	Institutes forests.	Association forests.	Private forests.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Prussia	0.9	30.9	13.3	1.2	2.9	50.8
East Prussia	.....	59.5	5.3	0.8	0.5	33.9
West Prussia	.....	60.6	4.3	0.3	0.2	34.6
Brandenburg	3.3	30.0	12.0	0.9	0.2	53.6
Pomerania	1.4	31.2	8.7	1.1	0.1	57.5
Posen	0.1	32.2	2.1	1.4	.....	64.2
Silesia	1.4	13.1	7.9	1.0	0.1	76.5
Saxony	0.4	32.1	9.3	1.2	2.4	54.6
Schleswig-Holstein	.....	28.7	10.7	1.4	0.2	59.0
Hanover	.....	36.4	7.1	3.2	14.1	39.2
Westphalia	.....	8.7	9.8	0.9	9.5	71.1
Hesse-Nassau	.....	42.0	34.2	2.0	6.6	15.2
Rhineland	.....	18.2	39.5	0.7	3.1	38.5
Hohenzollern	.....	.....	49.3	1.6	2.2	46.9
Bavaria	0.1	33.8	12.5	1.9	0.8	50.9
Upper Bavaria	.....	38.3	2.2	1.4	0.1	58.0
Lower Bavaria	.....	19.3	0.8	1.2	.....	78.7
Pfalz	.....	49.5	36.8	0.4	0.2	13.1
Oberpfalz	.....	33.4	2.4	2.2	0.1	61.9
Oberfranken	.....	38.6	4.6	1.5	1.0	54.3
Mittelfranken	0.3	31.8	14.0	1.7	0.5	51.7
Unterfranken	.....	32.0	36.7	2.6	3.6	25.1
Suabia	0.2	30.4	16.9	4.3	1.8	46.4
Saxony	.....	45.2	6.0	2.6	0.2	46.0
Wurttemberg	1.1	31.2	29.7	2.4	1.2	34.4
Baden	1.5	16.9	45.1	3.3	0.3	32.9
Hesse	27.7	2.1	36.2	0.3	0.9	32.8
Mecklenburg-Schwerin	3.2	42.0	9.6	5.0	.....	40.2
Saxe-Weimar	.....	47.5	15.3	1.7	1.4	34.1
Mecklenburg-Strelitz	2.1	66.0	7.9	0.3	.....	23.7
Oldenburg	0.5	37.7	10.6	0.8	.....	50.4
Brunswick	.....	73.5	1.5	0.2	16.3	8.5
Saxe-Meiningen	0.1	42.4	23.4	0.7	8.9	24.5
Saxe-Altenburg	31.3	17.3	2.1	2.6	1.4	45.3
Saxe-Coburg-Gotha	5.7	58.3	12.4	0.6	6.0	17.0
Anhalt	34.0	41.2	2.1	1.2	0.1	21.4
Schwarzburg-Sondershausen	62.7	0.5	12.8	1.0	10.7	12.3
Schwarzburg-Rudolstadt	.....	47.3	11.2	1.1	2.1	38.3
Waldeck	.....	62.5	21.5	0.5	1.8	13.7
Reuss (elder line)	38.6	.....	1.1	2.4	.....	57.9
Reuss (younger line)	52.9	.....	3.3	2.2	.....	41.6
Schaumburg-Lippe	94.0	.....	.....	.....	.....	6.0
Lippe	42.0	3.4	10.9	0.4	1.5	41.8
Lubeck	.....	71.8	0.1	13.3	.....	14.8
Bremen	.....	.....	.....	.....	.....	100.0
Hamburg	.....	59.3	6.3	0.5	.....	33.9
Alsace-Lorraine	.....	34.6	44.7	0.6	.....	20.1
German Empire	1.8	31.9	16.1	1.5	2.2	46.5

The forest area has changed comparatively little since 1878. In some parts of the Empire there has been a decrease, but in the country as a whole there has been a steady increase. The following table shows the changes mentioned:

Increase, in acres, in forest area of German Empire.

	Total wooded area.	Increase.
1878	34,682,315.0	.....
1883	34,770,995.0	88,680.0
1893	34,892,067.5	121,072.5
1900	34,989,670.0	97,602.5
Total	.....	307,355.0

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The Government has determined the area that may be converted into forests. This potential forest area has been computed at 1,583,000 acres, or 4½ per cent of the present total forest. Of this, 1,362,500 acres are in Prussia alone, which would increase the present forest area by 6.6 per cent. Prussia is doing a great deal in bringing under forest much of its waste land. Thus from 1867 to 1892, 336,582 acres of waste land were bought at $16 per acre to plant to forest, and from 1883 to 1902, 182,782 acres were brought under forest, or an average of 9,140 acres per year. On October 1, 1903, the Prussian forest administration possessed 91,202 acres of waste land, which it intended to plant with trees.

COMPOSITION.

Of the forests, 32½ per cent are covered with hard woods and 67½ per cent with conifers. The constant tendency is to increase the latter at the expense of the former.

The following figures show the progress made in this dirction:

	Hard woods.	Conifers.
	Acres.	*Acres.*
1883	12,006,450	22,764,545
1893	11,668,025	23,207,800
1900	8,862,000	23,627,673

Thus in 1883 the hard woods occupied 34½ per cent instead of 32½ per cent, and the conifers 65½ per cent instead of the present 67½ per cent. The remainder of the forest, comprising 2,699,997 acres, is a mixed composition of hard wood and conifers. In the following table are given detailed figures of the composition of the forest and the areas under different methods of management:

Percentage of forest composition by States.

States and Provinces.	Hard woods.				
	Total.	Coppice.	Composite forest.	Selection forest.	High forest.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Prussia	30.9	7.9	2.6	3.0	17.4
East Prussia	20.3	3.1	1.3	3.4	12.5
West Prussia	11.1	2.0	.5	1.6	7.0
Brandenburg	7.3	1.2	.2	.6	5.3
Pomerania	25.6	3.2	2.4	4.4	15.6
Posen	12.5	2.1	1.5	2.0	6.9
Silesia	12.6	5.1	3.3	1.3	2.9
Saxony	27.9	3.9	5.0	4.1	14.9
Schleswig-Holstein	64.5	6.8	4.9	10.4	42.4
Hanover	36.2	3.6	4.1	3.6	24.9
Westphalia	67.2	22.2	5.1	10.2	29.7
Hesse-Nassau	65.9	8.6	1.1	1.4	54.8
Rhineland	73.5	34.3	4.8	3.5	30.9
Hohenzollern	41.0	1.3	1.0	3.4	35.3
Bavaria	24.6	4.6	7.6	1.2	11.2
Upper Bavaria	7.5	2.0	1.2	4.3	
Lower Bavaria	16.5	1.3	1.1	14.1	
Oberpfalz	3.9	.7	.6	2.6	
Oberfranken	13.5	4.0	3.4	6.1	
Mittelfranken	17.8	3.5	6.4	7.9	
Unterfranken	65.6	11.3	17.7	36.6	
Suabia	25.5	4.5	8.3	12.7	

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Percentage of forest composition by States—Continued.

States and Provinces.	Hard woods.				
	Total.	Coppice.	Composite forest.	Selection forest.	High forest.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Saxony	11.3	4.5	3.4	1.3	2.1
Wurttemburg	38.5	.8	12.7	1.9	23.1
Baden	50.3	8.6	10.1	.3	31.3
Hesse	58.4	10.3	.2	.1	47.8
Mecklenburg-Schwerin	36.6	9.0	2.7	1.9	23.0
Mecklenburg-Strelitz	35.8	7.6	4.5	2.1	21.6
Saxe-Weimar	35.4	3.2	9.3	4.3	18.6
Oldenburg	50.9	16.6	.5	.....	33.8
Braunschweig	59.4	.5	8.1	1.0	49.8
Saxe-Meinigen	24.8	2.0	10.4	2.2	10.2
Alsace-Lorraine	66.9	6.2	22.8	.5	37.4
German Empire	32.5	6.8	5.0	2.3	18.4
1893	33.5	6.0	5.5	22.0	
1883	34.5	6.5	6.5	21.5	

States and Provinces.	Conifers.						
	Total.	Selection forest.	High forest.	Pine.	Larch.	Spruce.	Fir.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Prussia	69.1	8.5	60.6	57.5	0.1	11.2	0.2
East Prussia	79.7	17.9	61.8	51.0	.....	28.4	.4
West Prussia	88.9	8.2	80.7	88.0	.....	.8	.1
Brandenburg	92.7	9.7	83.0	92.3	.....	.4	.....
Pomerania	74.4	11.2	63.2	72.0	.....	.2	.1
Posen	87.5	12.0	75.5	86.9	.1	.4	.1
Silesia	87.4	8.1	79.3	71.5	.3	15.2	.4
Saxony	72.1	9.2	62.9	59.8	.1	12.1	.1
Schleswig-Holstein	35.5	5.1	30.4	15.5	.1	19.5	.3
Hanover	63.8	9.4	54.4	46.5	.2	16.9	.2
Westphalia	32.8	7.5	25.3	14.6	.3	17.6	.3
Hesse-Nanssau	34.1	.9	33.2	16.6	.2	17.3	.....
Rhineland	26.5	2.0	24.5	11.9	.1	14.3	.2
Hohenzollern	59.0	3.5	55.5	8.8	.....	40.8	9.4
Bavaria	75.4	8.0	67.4	30.0	.1	40.5	4.8
Upper Bavaria	92.5	.....	.....	10.3	1.0	81.2	
Lower Bavaria	83.5	.....	.....	19.2	.7	63.6	
Oberpfalz	96.1	.....	.....	61.2	.4	34.5	
Oberfranken	86.5	.....	.....	39.7	.2	46.6	
Mittelfranken	82.2	.....	.....	53.4	.3	28.5	
Unterfranken	34.4	.....	.....	25.1	.8	8.5	
Suabia	74.5	.....	.....	3.5	.4	70.6	
Saxony	88.7	10.0	78.7	30.0	.2	58.1	.4
Wurttemburg	61.5	5.5	56.0	8.6	.1	39.9	12.9
Baden	49.7	3.2	46.5	11.6	.1	25.6	12.4
Hesse	41.6	.....	41.6	34.1	.2	7.3	.....
Mecklenburg-Schwerin	63.4	2.2	61.2	60.4	.1	2.5	.4
Mecklenburg-Strelitz	64.2	2.5	61.7	63.7	.....	.5	.....
Saxe-Weimar	64.6	4.7	59.9	39.4	.1	24.8	.3
Oldenburg	49.1	.....	49.1	43.9	.2	5.0	.....
Braunschweig	40.6	1.6	39.0	7.4	.1	33.1	.....
Saxe-Meinigen	75.2	18.0	57.2	27.4	.5	46.8	.4
Alsace-Lorraine	33.1	.5	32.6	11.1	.....	2.8	19.2
German Empire	67.5	7.4	60.1	44.6	.1	20.1	2.7
1893	66.5	.....	.....	41.8	.3	22.5	
1883	65.5	.....	.....	42.6	.3	22.6	

ANNUAL CUT.

The total cut as given for the year 1899–1900 is 1,706,431,900 cubic feet of timber, or 48.7 cubic feet per acre. The following tables give a clear idea of the annual cut for the whole Empire, as well as for the different States comprising it:

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Yield of wood, 1899–1900.

	Actual amount.	Total cut.	Amount per acre.
	Cubic feet.	*Per cent.*	*Cubic feet.*
Timber (nutzholz) [a]	706,631,729	41.4	20.2
Firewood	630,127,804	36.9	17.9
Total of wood over 2¾ inches diameter (derbholz) [a]	1,336,759,533	78.3	38.1
Stump and fagot wood	369,672,367	21.7	10.6
Total production	1,706,431,900	100.0	48.7

[a] Derbholz is a general term for all wood over 2¾ inches in diameter at the small end; therefore this term will cover saw logs, mine timber, posts, poles, and also such firewood as exceeds this dimension. Nutzholz applies only to saw-log timber, in distinction from all other kinds of derbholz.

Yield of all German forests, by States, for the year 1899–1900.

States.	Timber.	Per cent of derbholz.	Firewood.	Per cent of derbholz.
	Cubic feet.		*Cubic feet.*	
Prussia	341,033,000	53.5	296,308,000	46.5
Bavaria	153,025,000	53.0	135,976,000	47.0
Saxony	36,818,000	75.1	12,214,000	24.9
Wurttemberg	44,972,000	55.1	36,712,000	44.9
Baden	39,889,000	48.0	43,243,000	52.0
Hesse	10,308,000	35.7	18,532,000	64.3
Mecklenburg-Schwerin	9,460,000	33.2	19,062,000	66.8
Saxe-Weimar	5,825,000	55.8	4,624,000	44.2
Mecklenburg-Strelitz	2,365,000	40.8	3,424,000	59.2
Oldenburg	1,447,000	54.7	1,200,000	45.3
Brunswick	7,272,000	49.2	7,519,000	50.8
Saxe-Meiningen	6,883,000	57.3	5,119,000	42.7
Saxe-Altenburg	3,177,000	67.7	1,518,000	32.3
Saxe-Coburg-Gotha	3,636,000	55.4	2,930,000	44.6
Anhalt	3,106,000	52.7	2,789,000	43.7
Schwarzburg-Sondershausen	1,694,000	58.5	1,200,000	41.5
Schwarzburg-Rudolstadt	2,612,000	67.3	1,271,000	32.7
Waldeck	1,024,000	33.7	2,012,000	66.3
Reuss (elder line)	812,000	74.2	282,000	25.8
Reuss (younger line)	3,459,000	82.4	741,000	17.6
Schaumberg-Lippe	494,000	63.6	282,000	36.4
Lippe	1,165,000	36.7	2,012,000	63.3
Lubeck, Bremen, and Hamburg	141,000	26.7	388,000	73.3
Alsace-Lorraine	25,946,000	45.8	30,676,000	54.2
German Empire	706,635,000	52.9	630,140,000	47.1

States.	Total yield of derbholz.	Derbholz per acre.	Stump and fagot wood.	
			Total.	Per acre.
	Cubic feet.	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*
Prussia	637,341,000	30.8	225,108,000	10.9
Bavaria	289,001,000	46.9	17,085,000	2.8
Saxony	49,032,000	51.0	16,485,000	16.9
Wurttemberg	81,684,000	54.4	21,498,000	14.3
Baden	83,132,000	58.6	22,416,000	15.7
Hesse	28,840,000	48.0	13,449,000	22.5
Mecklenburg-Schwerin	28,522,000	48.1	6,460,000	10.9
Saxe-Weimar	10,449,000	44.9	3,742,000	16.0
Mecklenburg-Strelitz	5,789,000	37.3	741,000	4.8
Oldenburg	2,647,000	15.5	1,447,000	8.5
Brunswick	14,791,000	54.2	4,907,000	17.9
Saxe-Meiningen	12,002,000	46.2	4,306,000	16.7
Saxe-Altenburg	4,695,000	52.2	1,765,000	19.8
Saxe-Coburg-Gotha	6,566,000	44.1	2,436,000	16.2
Anhalt	5,895,000	40.8	2,153,000	14.8
Schwarzburg-Sondershausen	2,894,000	43.3	565,000	8.8
Schwarzburg-Rudolstadt	3,883,000	37.6	1,200,000	11.9
Waldeck	3,036,000	28.4	1,624,000	15.2
Reuss (elder line)	1,094,000	39.0	459,000	15.8
Reuss (younger line)	4,200,000	54.2	1,977,000	25.5
Schaumberg-Lippe	776,000	45.0	459,000	27.0
Lippe	3,177,000	38.0	988,000	11.7
Lubeck, Bremen, and Hamburg	529,000	35.7	459,000	30.5
Alsace-Lorraine	56,622,000	51.5	17,897,000	16.4
German Empire	1,336,775,000	38.1	369,662,000	10.6

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Yield of the German forests according to ownership, 1900.

	Yield per acre.	Derbholz—		Stump and fagot wood per acre.	Yield per acre.	Timber.	Total yield—	
		Timber.	Firewood.				Split and round firewood.	Stump and fagot wood.
	Cubic feet.	*Per cent.*	*Per cent.*	*Cubic feet.*	*Cubic feet.*	*Per cent.*	*Per cent.*	*Per cent.*
Crown forests	46.9	52.0	48.0	16.7	64.5	38.4	35.4	26.2
State and state managed	48.6	57.1	42.9	9.9	58.5	47.4	35.7	16.9
Communal	37.7	43.8	56.2	15.4	53.1	31.1	40.0	28.9
Institution	47.0	51.2	48.8	13.2	60.3	39.9	38.1	22.0
Association	29.1	35.8	64.2	15.4	44.5	23.4	42.0	34.6
Private	31.1	53.1	46.9	8.8	39.8	41.3	36.6	22.1
Entailed or in trust	42.9	55.9	44.1	10.7	53.4	44.7	35.3	20.0
Other private forests	27.7	51.8	48.2	8.3	36.0	39.9	37.1	23.0

The state forests evidently yield the largest per cent of timber.

Contribution of each class of ownership to total wood production of the German Empire.

	Timber.		Firewood.		Total derbholz.		Stump and fagot cited.		Per cent of the total wood area.
	Cubic feet.	Per cent.	Cubic feet.	Per cent.	Cubic feet.	Per cent.	Cubic feet.	Per cent.	
Crown, state, and part state forests	324,689,000	45.9	246,959,000	39.2	571,648,000	42.8	121,079,000	32.8	33.7
Communal and institution	105,794,000	15.0	131,669,000	20.9	237,463,000	17.7	93,616,000	25.3	17.6
Association	7,978,000	1.1	14,332,000	2.3	22,310,000	1.7	11,755,000	3.2	2.2
Private	268,139,000	38.0	237,181,000	37.6	505,320,000	37.8	143,212,000	38.7	46.5
German Empire	706,600,000	100.0	630,141,000	100.0	1,336,741,000	100.0	369,662,000	100.0	100.0

This shows that the state forests, with only 33.7 per cent of the total forest area, produce 43 per cent of the derbholz and 46 per cent of the timber; while the private forests, with 46.5 per cent of the total area, produce only 38 per cent of derbholz and of timber.

Timber yield of the German state forests in percentage of the total wood yield and of the yield of material over 2¾ inches in diameter.

Year.	Prussia.		Bavaria.		Saxony.	Wurttemberg.	Baden.		Alsace-Lorraine.	Brunswick.
	Total yield.	Yield over 2¾ inches.	Total yield.	Yield over 2¾ inches.	Yield over 2¾ inches.	Yield over 2¾ inches.	Total yield.	Yield over 2¾ inches.	Total yield.	Yield over 2¾ inches.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1890	36	47	40	46	80	54	34	42	40	.....
1891	36	46	50	55	79	51	32	39	38	.....
1892	36	46	50	55	79	54	32	39	54	.....
1893	36	47	37	43	78	52	32	39	39	.....
1894	44	53	40	46	78	52	33	40	38	.....
1895	41	51	42	48	79	53	37	44	41	52
1896	40	50	45	50	79	52	40	47	42	54
1897	43	54	46	51	70	54	41	49	43	55
1898	45	56	44	50	81	56	40	47	47	53
1899	47	60	45	51	81	57	40	48	47	50
1900	48	60	45	52	82	58	40	47	44	52
1901	48	59	42	48	80	57	38	46	39	50
1902	45	55	43	49	79	58	42	50	47	50
1903	.....	.....	.....	.....	.....	.....	.....	.....	52	.....

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Yield according to species.—The average yield of derbholz (wood over 2¾ inches in diameter) is greater for conifers than for the broadleaf species. The yield of the State forests in Wurttemberg per acre gives the following result:

Yield of State forests per acre.

Year.	Broadleaf species.			Conifers.		
	Total yield.	Wood over 2¾ inches diameter.	Fagot wood.	Total yield.	Wood over 2¾ inches diameter.	Fagot wood.
	Cubic feet.	*Cubic feet.*	*Per cent.*	*Cubic feet.*	*Cubic feet.*	*Per cent.*
1861–70	.....	40.9	.....	.....	72.0	.....
1874–76	59.3	40.9	31	91.8	81.9	11
1882	60.2	40.2	33	84.6	74.0	13
1888	72.6	53.4	27	91.8	79.6	13
1895	71.9	53.1	26	85.7	74.0	15
1900	77.0	59.4	23	91.4	78.5	14
1901	78.9	60.2	24	97.4	82.9	15

Forests in coppice and compound coppice yield less than high forests; e. g., in the state forests of Baden the yield per acre for high forests from 1892 to 1896 was 79.5 cubic feet, and from 1879 to 1901, 91.2 cubic feet; for coppice and compound coppice, from 1892 to 1896, 55.1 cubic feet, and from 1897 to 1901, 65.7 cubic feet.

The German Empire, with an annual production of 48.7 cubic feet per acre, shows the highest wood production of all European countries. Of the different kinds of forests, the state and crown forests produce the greatest amount of wood per acre per year—64½ cubic feet against 39.8 cubic feet in private forests. At the same time the state forests produce the largest percentage of saw-log timber—57.1 per cent against 53.1 per cent in private forests. Of all the States Saxony produces the largest proportion of saw-log timber. The different States may be arranged in the order of their production of saw-log timber as follows:

Distribution of saw-log timber by States.

States.	Per cent.	States.	Per cent.
Saxony	75	Brunswick	49
Saxe-Meiningen	57	Baden	48
Wurttemberg	55	Alsace-Lorraine	46
Prussia	54	Hesse	36
Bavaria	53	Mecklenburg-Schwerin	33

Although Prussia includes 59.1 per cent of the forest area of the Empire, it furnishes only 47.6 per cent of the total production of timber over 2¾ inches, and only 48.3 per cent of the timber production of the Empire; in each case less than half.

Bavaria, Wurttemberg, Baden, Alsace-Lorraine, Hesse, and Saxony, which together include 33.5 per cent of the total forest area, produce 44 per cent both of wood over 2¾ inches and of timber.

The largest percentage of saw-log timber does not necessarily mean production of the largest amount of all kinds of wood over 2¾ inches in diameter at the small end.

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In the following table States with over 250,000 acres of woodland are arranged according to the production of derbholz:

Distribution of derbholz by States.

States.	Cubic feet per acre.	States	Cubic feet per acre.
Baden	58.4	Hesse	48.0
Wurttemberg	54.4	Bavaria	46.9
Brunswick	54.2	Pfalz	44.2
Alsace-Lorraine	51.5	On the right of the Rhine	47.0
Saxony	51.0	Saxe-Meiningen	46.2
Mecklenburg-Schwerin	48.1	Prussia	30.8

ANNUAL GROWTH AND PRESENT STAND.

Since the principle underlying the management of practically all the forests is to cut merely the annual increment and to leave intact the forest capital, it may be safely assumed that the annual cut is equal to the annual growth. In some cases the annual cut has been made smaller than the annual increment, in order to increase the forest capital so as to produce larger annual increments in the future.

The total present stand is given in the "Worterbuch der Volkswirtshaft" (Prof. D. L. Elster, Jena, Achte Lieferung, 1899), at a forest rotation of eighty to one hundred years, as from 70,000,000,000 to 105,000,000,000 cubic feet. Professor Elster assumes an annual growth of 50 cubic feet per acre, which corresponds very closely with the figure given above, 48.7 per cent. The average rotation may be taken as ninety years, but even this is too long, since there are many broadleaf forests which do not demand such long rotations. At an annual growth of 50 cubic feet and a rotation of ninety years, the forests will have a stand of about 79,000,000,000 cubic feet. At an average price even as low as 7 cents per cubic foot the German forests represent a capital of $5,530,000,000,[a] not counting the value of the land.

ANNUAL CONSUMPTION.

In spite of the fact that the German Empire succeeds in producing the largest amount of wood per acre, it is unable to supply its own needs for saw timber. Since 1863 the imports have exceeded the exports and the difference between them has been growing steadily. In 1904 this excess in saw-log timber (logs, sawn timber, and hewn timber) amounted to 4,726,000 tons, or 357,690,300 cubic feet (one ton being equal to about 75 cubic feet of round timber). This, together with the 1,706,431,900 cubic feet cut in Germany itself, gives a total home consumption of 2,064,122,300 cubic feet of wood of all kinds, or 36.6 cubic feet per capita. The consumption of saw-log timber alone is 1,064,322,000 cubic feet, or 18.8 cubic feet per inhabitant. The consumption of fuel alone is 999,800 cubic feet, or 17.8 cubic feet per capita.

[a] $\text{Stand} = \frac{\text{annual increment} \times \text{area} \times \text{rotation}}{2}$.

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WOOD PRICES.

The two following tables give the wood prices in the state forests in the different States. The second table gives the average prices of wood, irrespective of the kind and species, for a period covering seventy-four years—1830–1903. The average prices for wood of all kinds do not vary a great deal. For 1902 the prices ranged from 5 cents per cubic foot in Prussia to 10 cents in Saxony, the prevailing price being about 7 cents. The first table gives the average sale prices as they prevailed in 1902 in the state forests for saw-log timber and firewood of different species. The highest saw-log prices were secured for oak timber, and the highest firewood prices were secured for oak and beech wood.

Prices of wood of different species and kinds in Prussia and Wurttemberg.

Year.	Prussia.							Wurttemberg.			
	Saw-log timber.				Firewood.			Saw-log timber.		Billets and fagots.	
	Oak.	Beech.	Spruce.	Pine.	Beech.	Spruce.	Pine.	Oak.	Conifers.	Beech.	Conifers.
	Price per cubic foot.				Price per cord.			Price per cubic foot.		Price per cord.	
1855–59	.....	.....	.....	.....	.....	.....	.....	$0.131	$0.079	$4.32	$2.52
1860–64	.....	.....	.....	.....	.....	.....	.....	.172	.106	5.67	3.60
1865–69	.....	.....	.....	.....	.....	.....	.....	.161	.090	6.03	3.51
1870	.....	.....	.....	.....	.....	.....	.....	.177	.083	6.75	3.15
1871	.....	.....	.....	.....	.....	.....	.....	.158	.079	6.84	3.15
1872	.....	.....	.....	.....	.....	.....	.....	.188	.078	5.76	3.15
1873	.....	.....	.....	.....	.....	.....	.....	.225	.102	7.47	4.14
1874	.....	.....	.....	.....	.....	.....	.....	.209	.121	7.56	4.86
1875	.....	.....	.....	.....	.....	.....	.....	.200	.128	8.82	5.49
1876	.....	.....	.....	.....	.....	.....	.....	.203	.106	9.63	5.13
1877	.....	.....	.....	.....	.....	.....	.....	.198	.098	8.01	3.96
1878	.....	.....	.....	.....	.....	.....	.....	.195	.102	.....	.....
1879	.....	.....	.....	.....	.....	.....	.....	.171	.085	.....	.....
1880	.....	.....	.....	.....	.....	.....	.....	.179	.088	.....	.....
1881	.....	.....	.....	.....	.....	.....	.....	.179	.089	5.49	3.24
1882	.....	.....	.....	.....	.....	.....	.....	.176	.088	5.31	3.15
1883	$0.137	$0.088	$0.080	$0.064	$4.05	$2.61	$2.88	.173	.092	5.40	3.60
1884	.135	.085	.078	.065	4.32	2.97	3.06	.181	.090	5.58	3.87
1885	.132	.081	.075	.064	4.32	2.79	3.33	.180	.093	5.58	3.78
1886	.126	.078	.084	.065	4.23	2.79	3.15	.179	.092	5.85	3.78
1887	.125	.078	.084	.064	4.14	2.70	2.79	.169	.086	5.40	3.06
1888	.130	.083	.093	.067	4.05	2.61	2.88	.198	.097	5.49	3.24
1889	.142	.079	.099	.071	4.14	2.43	3.06	.198	.104	5.67	3.60
1890	.143	.083	.099	.074	4.23	2.61	3.24	.223	.109	5.67	4.05
1891	.144	.077	.099	.069	4.50	2.88	3.51	.230	.097	6.03	4.32
1892	.141	.090	.088	.071	4.50	2.70	3.24	.249	.102	6.57	4.77
1893	.132	.080	.085	.069	4.32	2.52	2.97	.249	.105	6.66	4.86
1894	.128	.078	.081	.061	4.14	2.34	2.70	.251	.113	6.21	4.59
1895	.134	.078	.090	.067	4.41	2.61	2.70	.237	.116	6.75	4.95
1896	.134	.082	.097	.071	4.50	2.70	2.79	.239	.119	6.48	5.04
1897	.144	.088	.107	.076	4.59	2.79	3.15	.245	.128	6.12	5.04
1898	.146	.091	.109	.083	4.50	2.79	3.60	.253	.135	6.12	5.04
1899	.148	.087	.113	.083	4.59	2.88	4.05	.269	.143	6.30	5.04
1900	.154	.088	.113	.098	5.04	3.06	4.50	.255	.139	7.02	5.49
1901	.134	.088	.097	.086	5.31	3.24	4.14	.254	.133	8.28	6.12
1902	.139	.084	.096	.078	4.68	2.97	3.33	.....	.....	.....	.....

The figures for value per cord are about 4 per cent too high because the reducing factor .9 was used instead of 0.864. The figures for values per cubic foot are 4 per cent too high because the factor 0.007 was used instead of 0.006+.

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Average prices per cubic foot of wood, irrespective of kind or species, in the state forests of the different States of the German Empire.

Year.	Prussia.	Bavaria.	Saxony.	Baden.	Alsace-Lorraine.	Year.	Prussia.	Bavaria.	Saxony.	Baden.	Alsace-Lorraine.
1830	$0.02	.....	$0.04	.....	.....	1867	$0.04	$0.03½	$0.07	$0.06	.....
1831	.02	.....	.04	.....	.....	1868	.04½	.03½	.07½	.06	.....
1832	.02	.....	.04½	.....	.....	1869	.04	.03½	.06	.06	.....
1833	.02	.....	.04½	.....	.....	1870	.04	.04	.05½	.06½	.....
1834	.02	.....	.04	.....	.....	1871	.04	.04	.07½	.06½	.....
1830–34	.02	.....	.04½	.....	.....	1866–71	.04	.04	.07	.06	.....
1835	.02½	.....	.04	.....	.....	1872	.04	.04	.09½	.07½	$0.06½
1836	.02½	.....	.04½	.....	.....	1873	.04½	.05	.11½	.08	.06½
1837	.02½	.....	.04½	.....	.....	1874	.05	.05½	.11	.08½	.08
1838	.02½	.....	.05	.....	.....	1875	.05	.05½	.11½	.09	.08
1839	.02½	.....	.05	.....	.....	1872–75	.04½	.05	.11	.08½	.08
1835–39	.02½	.....	.04½	.....	.....	1876	.04	.06	.08½	.08½	.08
1840	.02½	.....	.05½	.....	.....	1877	.04	.05	.08½	.07	.06
1841	.03	.....	.05½	.....	.....	1878	.04	.05	.08½	.07	.06½
1842	.03	.....	.05½	.....	.....	1879	.04	.05	.08	.06½	.06½
1843	.03	.....	.05½	.....	.....	1876–79	.04	.05½	.08½	.07½	.06½
1844	.03	.....	.04	.....	.....	1880	.04	.05	.08½	.06½	.06½
1840–44	.03	.....	.05½	.....	.....	1881	.04	.05	.08½	.06	.06
1845	.03	.....	.05½	.....	.....	1882	.04	.05	.08½	.06	.06
1846	.03	.....	.06	.....	.....	1883	.04	.05	.09½	.06½	.06
1847	.03	.....	.05½	.....	.....	1884	.04	.05	.09½	.06½	.06
1848	.03	.....	.05½	$0.03	.....	1885	.04	.05	.09½	.06½	.05½
1849	.02½	.....	.05½	.03	.....	1886	.04	.05	.09½	.06	.05½
1845–49	.03	.....	.05½	.....	.....	1880–86	.04	.05	.09	.06½	.06
1850	.03	$0.02	.05½	.03	.....	1887	.04	.05	.09	.05½	.05
1851	.03	.02	.06	.02	.....	1888	.04	.05	.09½	.06	.05½
1852	.03	.02½	.06	.02	.....	1889	.04½	.05	.10	.06½	.06
1853	.03	.02	.06	.02	.....	1890	.04½	.05½	.10	.06½	.06
1854	.03	.02½	.06	.04	.....	1891	.05	.05½	.10	.07	.07
1855	.03	.02½	.06	.04	.....	1892	.04½	.05½	.09	.07	.06½
1850–55	.03	.02½	.06	.03½	.....	1893	.04½	.05	.09	.07	.06
1856	.03	.03	.06	.04	.....	1894	.04½	.05½	.09	.07	.06
1857	.03	.03	.06	.05	.....	1888–94	.04½	.05	.09½	.07	.06
1858	.03	.03	.07	.05½	.....	1895	.04½	.05½	.09½	.07½	.07
1859	.03	.03	.07	.05½	.....	1896	.04½	.05½	.10½	.07½	.07
1860	.03	.03	.07	.06	.....	1897	.05	.05½	.11	.07½	.07½
1861	.03½	.03½	.07½	.06½	.....	1895–97	.04½	.05½	.....	.07½	.07
1862	.03½	.03½	.07½	.06	.....	1898	.05½	.06	.10½	.08	.07½
1856–62	.03	.03	.07	.05½	.....	1899	.06	.06½	.11	.08	.08
1863	.03½	.04	.08	.06	.....	1900	.06½	.07	.11½	.08½	.08
1864	.04	.04	.08	.07	.....	1901	.06	.07	.11	.08½	.08
1865	.04	.05	.09	.07½	.....	1902	.05	.07	.10	.07½	.07
1863–65	.04	.04	.08½	.07	.....	1903	.06	.....	.11	.....	.07
1866	.04	.04	.08½	.06½	.....						

These are average prices obtained in the state forests, including the cost of cutting and working up the timber and delivering it along the road. They refer in Prussia and Bavaria to all kinds of wood, including stump wood, in Baden to all wood except stump wood, and in Saxony only to wood having a diameter of 2¾ inches at the small end.

FRANCE.

FOREST AREA.

The forests of France have increased to some extent since 1840, as may be seen from the following table:

Increase in forest areas, 1840–1903.

	Forest area.	Land area under forest.
	Acres.	*Per cent.*
1840	20,848,274	15.9
1862	23,026,445	17.2
1882	23,367,558	17.9
1903	24,021,587	18.2

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The forest area of France is considerably smaller than that of Germany or Austria-Hungary. In 1901 the per capita forest area was 0.63 acre. The total area was distributed among different owners as follows: State forests, 2,889,470 acres, or 12.0 per cent; communal forests, 5,589,392 acres, or 23.3 per cent; and private forests, 15,542,725 acres, or 64.7 per cent.

Of state forests, a large part is poorly or not at all forested; the unproductive area is estimated as 662,000 acres, or nearly 23 per cent of the total area, while in the communal forests it amounts to 275,000 acres. Most of the state forests are in the departments of Ariege (203,750 acres), in the Pyrenees, Basses-Alpes (116,328 acres), Vosges (141,180 acres), Cote-d'Or (100,743 acres), farther Loiret (96,582 acres), and Corsica (111,890 acres).

The most of the communal and institution forests are in the eastern departments of Vosges (296,638 acres), Haute Saone (287,757 acres), Cote-d'Or (251,815 acres), Savoie (188,098 acres), Doubs (249,600 acres), Hautes-Alpes (197,948 acres), Jura (215,333 acres), Meuse (242,115 acres), in the more distant parts of the three departments of the Pyrenees (322,360 acres), and in Corsica (203,405 acres).

The smallest amount of private forest is found in the department of Vosges.

COMPOSITION.

Of the total area, 20 per cent is stocked with conifers and 80 per cent with hard woods (35 per cent of this is the ordinary oak and 4 per cent of the stone oak *Quercus ilex.*) In the state forests conifers occupy 23.4 per cent of the total area (fir 7 per cent, Scotch pine 6.6 per cent, maritime pine 4 per cent, spruce 2.7 per cent, larch 1.8 per cent, other conifers 1.3 per cent); broadleaf forests 76.6 per cent (oak 27.4 per cent, beech 18.3 per cent, hornbeam 10.9 per cent, evergreen oak (*Q. ilex*) 4 per cent, other hard woods 16 per cent). In private forests conifers form 19 per cent, hard woods 81 per cent.

According to the system of management practiced, the forests show the following proportions in state, private, and communal forests:

Distribution of forests by management.

	State forest.	Forests under state control.	Private forest.	Total forest area.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Coppice	2.5	14.7	49.0	38.0
Composite forest	29.2	53.2	31.0	35.0
Conversion forest	16.8	1.0	.....	2.0
High forest	51.5	31.1	20.0	25.0

ANNUAL CUT.

The total annual cut in France amounts to 910,740,000 cubic feet, of which 225,920,000 cubic feet are timber, or a total cut of 39.39 cubic feet per acre. The cut varies in the different forests, as can be seen from the following figures:

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Annual cut per acre by ownership.

	Total cut per acre of forest area.	Timber.
	Cubic feet.	*Per cent.*
State forest	43.07	35
Forests under state control	36.57	24
Private forests	40.95	25
Average	39.39	25

ANNUAL GROWTH.

While France has still much work to do before she can bring the exploitation of her forests to the point the German forests have reached, it can hardly be doubted that the present cut does not exceed the annual growth. The present yield of 910,740,000 cubic feet per year may, therefore, be considered equivalent to the total annual growth. The chief task which France has in the future is to produce a larger amount of saw-log timber in proportion to cord wood, which has a small value. The 910,740,000 cubic feet of home product are not sufficient to supply all her needs, and it is necessary to import wood for home consumption. Not counting firewood and charcoal, France has at present on an average every year a surplus of imports over exports of 44,000,000 cubic feet in round numbers. On an average, between 1894 and 1898, the following amounts of the different kinds of wood were exported and imported:

Exports and imports of wood, in cubic feet.

In form of—	Exports.	Imports.	Surplus of imports over exports.
Sawn lumber	3,277,000	74,509,000	.....
Logs and other round timber	43,747,000	6,721,000	.....
Staves	212,000	6,011,000	.....
Other wood, except firewood and charcoal	3,101,000	8,650,000	.....
Total of all kinds of wood	50,337,000	95,891,000	45,554,000

As regards firewood and charcoal, there were exported 5,129,000 cubic feet and imported 3,443,000 cubic feet; in other words, the exports exceeded the imports by 1,700,000 cubic feet, which reduces the surplus of imports over exports of all kinds of wood to 43,900,000 cubic feet.

The total home consumption, therefore, amounts to 910,740,000 plus 43,900,000 cubic feet, or a total of 954,640,000 cubic feet. The per capita consumption is 24.6 cubic feet, of which 17.7 cubic feet are firewood and 6.9 cubic feet are timber.

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WOOD PRICES.

The following table gives prices for saw-log timber of different species at point of shipment along the road:

Wood prices per cubic foot, according to size of log, at points of shipping for Paris market at city gates.

SAW LOGS.

Species.	Price.
Oak, heartwood	$0.28 to $0.42
Oak, sapwood	.42 to 1.10
Beech	.25 to .34
Ash	.17 to .34
Red elm	.20 to .34
White elm	.22 to .29
Scotch pine	.13 to .18
Spruce and fir	.18 to .30

RAILWAY TIES (1905).

Contents in cubic feet.	Price per tie.
4.0	$1 08
5.4	1 45
5.7	1 54
7.2	1 94
7.6	2 04

BELGIUM.

FOREST AREA.

The present forest area of Belgium shows an increase over that of 1846, as may be seen from the following:

1846, 1,200,268.8 acres; 1866, 1,074,057.3 acres; 1880, 1,209,556.8 acres; and 1895, 1,303,735.5 acres.

The forest area forms 17.7 per cent of the total land area, or 0.2 acre per inhabitant. The most wooded provinces are Luxemburg, 41 per cent, and Namur, 31 per cent, which together comprise 666,937 acres. Of the total forest area, 62,600 acres, or 4.8 per cent, are state forests; 395,452 acres, or 30.3 per cent, are communal forests; 17,370 acres, or 1.3 per cent, belong to public institutions; and 828,300 acres, or 63.5 per cent, are private forests.

COMPOSITION.

Of the total forest area, 71.1 per cent are hard woods and 28.9 per cent are conifers (pine predominating). Of the hard woods, 56 per cent was managed as composite forest, 31 per cent as sprout forest, and 13 per cent as high forest. Especially common is oak coppice wood, managed for bark, the production of which amounts to about 29,500 tons.

ANNUAL CUT.

The annual cut is estimated as 75,789,000 cubic feet, or 58.2 cubic feet per acre, of which saw-log timber forms 40 per cent, or 28,734,200

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cubic feet. In addition, some 7,415,100 cubic feet are obtained annually from trees outside of the forest, making the total cut 83,204,000 cubic feet.

ANNUAL GROWTH.

During recent years Belgium has manifested a strong tendency not only to husband her forests most rationally, but also to increase the forest area. The annual cut may, therefore, be taken as the annual growth. There are no recent figures regarding the productivity.

CONSUMPTION.

Home production is unable to satisfy the needs of the country. The consumption of mine timber alone in 1894 was 21,892,210 cubic feet and in 1903 it was 35,310,000 cubic feet. The excess of imports over exports of building timber in 1898 amounted to 36,400,126 cubic feet. The total consumption then amounts to 119,604,126 cubic feet, or 17.7 cubic feet per capita. Of this amount, 72,549,400 cubic feet, or 10.8 cubic feet per capita, consist of saw-log timber; while 47,055,000 cubic feet, or 6.9 cubic feet per capita, are cord wood.

WOOD PRICES.

The wood prices are very much the same as in Germany. The average price for all kinds, irrespective of species, is something like 6 cents per cubic foot in the forest. In Germany, as we have seen, the price of wood in the forest ranges between 5 and 8 cents, while cord wood in Prussia sells at about 3 cents.

SPAIN AND PORTUGAL.

The figures regarding the forests of Spain and Portugal are extremely conflicting; thus, according to K. van Scherzer,[a] the area of Spanish forests in 1885 was 26,098,200 acres, or 20.8 per cent of the total land area; and for Portugal, according to the same source, 1,756,000 acres, or 8 per cent of the total land area. According to A. Mélard,[b] the forest area in Spain may be taken as equal to 16,065,000 acres, and that of Portugal from 1,112,400 to 1,236,600 acres. Taking Melard's figures, it would seem that the forests of Spain occupy 13 per cent of the total land area and those of Portugal 5 per cent. According to Scott Keltie,[c] the forests of Portugal amounted to only 2.9 per cent of the total land area.

The Spanish peninsula is a plateau bordered by high mountain terraces. The rivers are unreliable, having neither glaciers nor great lakes at their sources. The rains are very unequally distributed over the different seasons. Drought is often followed by severe floods, and in order to counteract their bad effects Spain and Portugal should be well forested. Both countries, however, are lacking in this respect. As to the forest area per inhabitant, taking Mélard's figures for the areas, Spain, with a population of 18,090,000, has a forest area per capita of 0.88 acre, and Portugal, with a population of

[a] Das Wirthschaftliche Leben der Völker.
[b] Insufficance de la Production de bois d'œuvre.
[c] The Statesman's Yearbook for 1901.

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5,423,000, has only 0.23 acre. These figures can not, however, be considered reliable, and if Spain actually has nearly 0.9 acre for every inhabitant the forest must be uncommonly poor, because Spain has not enough timber to satisfy rather low home demands for wood. The forests probably meet a great deal of the local demand and furnish large amounts of cork for export, but on the whole they are not sufficient to supply the home consumption. The need for foreign timber will still further increase when Spain enters on an active exploitation of her mineral wealth.

There are no figures of any kind in regard to the annual cut, growth, or consumption for either country.

ITALY.

FOREST AREA.

According to Loreto Pasqualucci,[a] the forest area of Italy now comprises 11,034,900 acres, but this figure is higher than that given in the official Italian reports.[b] The official statistics[b] of this country give the area of forests as 10,115,404.2 acres, or 14.28 per cent of the total land area. The forest area per capita is 0.31 acre.

The government ownership of forests is of two kinds. One part of the state forests, 375,000 acres in extent, is under the direct control of the secretary of the treasury, and any portion of it may be sold whenever necessary; another part, much smaller in area, comprising only 40,000 acres, is declared inalienable, is directly under the secretary of agriculture, and is administered by the forest service. The largest state forest (28,245 acres) is in Tuscany, and two other large forests (one of 16,137 acres, the other of 14,840 acres) are in Venetia.

COMPOSITION.

Of the total forest area 52 per cent is managed as high forests and 48 per cent as composite and sprout forests. Of the high forest 30 per cent is coniferous, 62 per cent produces hard woods, and 8 per cent is mixed forest. The forests are thus shown to be principally hard woods.

ANNUAL CUT.

According to official statistics the following amounts were cut in all the forests: Saw-log timber, 48,525,000 cubic feet, or 4.8 cubic feet per acre; cord wood, 222,103,000 cubic feet, or 22 cubic feet per acre, and wood for charcoal, 106,621,000 cubic feet, or 10.5 cubic feet per acre, making a total of 377,249,000 cubic feet, or 37.3 cubic feet per acre.

In addition, by-products were obtained amounting to 1,708 tons. Thus enormous quantities of cord wood and wood for charcoal were obtained.

ANNUAL GROWTH.

There are no figures regarding the productivity of the forests. It can not, however, be very far from the annual cut.

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[a] Nuevo annuario del commercio dell' Italia (1895), L. Pasqualucci.
[b] Annuario Statisco Italiano 1898 ed., 1900.

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CONSUMPTION.

The 377,252,000 cubic feet which are cut at home are not sufficient to supply the needs of the home industries. Italy is compelled to import, though not to the same extent as England, Germany, France, and Belgium, because its industries are less developed. The average excess of imports of saw-log timber over exports, for a period of five years (1895 to 1899), was 27,023,000 cubic feet, and the yearly excess of imports of cord wood over exports for the same period was about 3,031,000 cubic feet. The total consumption of saw-log timber may therefore be taken as 75,548,000 cubic feet, or 2.4 cubic feet per capita. The total consumption of cord wood and wood for charcoal was 330,000,000 cubic feet, or 10.5 cubic feet per inhabitant. The aggregate consumption per capita is thus nearly 13 cubic feet.

WOOD PRICES.

No figures are available regarding the prices of wood.

NETHERLANDS.

FOREST AREA.

In the Netherlands for the last sixty-five years there has been a constant increase in the area of productive land at the expense of the noncultivated and waste land; thus, in 1833, fields, pastures, meadows, and forests occupied 63 per cent of the total land area, and the remaining 37 per cent was swamps, waste land, and roads, while in 1898, 72 per cent was under crops, forests, and gardens. In sixty-five years the Dutch have thus transformed 9 per cent of waste and unproductive land into profitable areas. Forests have also increased accordingly; in 1833 the forest area was 417,728 acres, or 5.2 per cent of the land area; in 1881 it was 552,001 acres, or 6.8 per cent of the land area; and in 1889 it was 617,567 acres, or 7.7 per cent of the land area.

The forest area in sixty-five years has increased about 50 per cent. Since the greater part is in the hands of private individuals, this increase must be taken as an indication that forestry is profitable. The per capita forest area is 0.1 acre.

COMPOSITION.

By species, the forests are distributed as follows: Two hundred and twelve thousand five hundred acres, or 37.8 per cent, are coniferous forests (pine), and 350,572 acres, or 62.2 per cent, are hard woods (chiefly oak). The sprout forest is the prevailing form of management. The oak sprout forest comprises 91,892 acres, or 16 per cent of the total forest area.

ANNUAL CUT AND GROWTH.

Unfortunately there are no reliable figures concerning the amount of annual cut. K. von Scherzer[a] estimated the cut in Holland and Belgium at 37 cubic feet per acre. Judging by the revenues obtained

[a] Das wirthschaftliche Leben der Völker.

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in the Belgian forests, the Dutch forests must yield a larger amount of wood per acre, at least 46 cubic feet. In that case the total cut would amount to 28,591,000 cubic feet. This figure may also be accepted as the annual growth, as the forests are managed for a sustained yield.

CONSUMPTION.

The annual yield is not sufficient to supply the home consumption. Holland is a highly commercial nation, but its industries are less developed than those of Belgium, and hence its wood consumption is smaller. Holland uses enormous quantities of coal and turf, and therefore does not use much wood for fuel, but it needs large quantities of timber for building purposes. The surplus average of imports of round timber over exports for five years (1895–99) was about 24,875,000 cubic feet, and that of sawed timber for the same period, 13,757,000 cubic feet, or in all 38,632,000 cubic feet. Adding to this the annual cut at home (28,591,000 cubic feet), the total consumption in Holland would be about 67,200,000 cubic feet, or, with a population of 5,100,000, 13.1 cubic feet per capita. Even assuming that 50 per cent of the total cut is cord wood, still the consumption of cord wood would form only 2.8 cubic feet, while the consumption of timber and lumber would be 10.3 cubic feet per capita.

WOOD PRICES.

Except the general import prices per cubic foot as they are obtainable by dividing the total value of imports by their volume, no other wood prices are available. The general import price for round timber was about 14 cents per cubic foot, and that of sawed timber about 18 cents.

SWITZERLAND.

FOREST AREA.

The Swiss forests occupy 20.6 of the total land area of 10,237,560 acres, or 2,140,012 acres, while in 1884 the forest area amounted to only 1,940,465 acres. In other words, the forest area has increased 10 per cent during the last fifteen years. The Government recognizes the necessity of keeping the mountain slopes covered with forests in order to avoid landslides, and therefore extends the area under forest by all possible means, chiefly by planting. Between 1878 and 1890, 10,000,000 conifers and 1,000,000 broadleaf trees were planted on an average every year. Since 1890 the planting has been done every year regularly. In 1899 about 14,000,000 pine seedlings, 2,000,000 spruce, 1,200,000 larch, and 1,400,000 fir and other trees were planted. The area planted during this whole time amounted to 4,153 acres, at a cost of $22.25 per acre. The forest area per capita is 0.65 acre.

Of the total forest area, the States own 97,630 acres, or 4.6 per cent; communes and corporations, 1,431,280 acres, or 66.9 per cent; and private individuals, 611,102 acres, or 28.5 per cent. The most heavily wooded cantons are Schaffhausen, Lolothurn, Basel-Land, and Aargau; the least thickly wooded are Genève and Uri. The distribu-

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tion of forests according to ownership in the different cantons is given as follows:

Distribution of forest in different cantons.

Cantons.	Forest area.	Land area under forest.	State forests.	Communal and corporation forests.	Private forests.
	Acres.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Zurich	117,150.0	27.2	4.8	41.4	53.8
Bern	380,295.0	22.1	8.5	52.0	39.5
Lucern	77,355.0	20.6	1.5	19.3	79.2
Uri	27,462.5	10.2	.7	88.3	11.0
Schevys	42,040.0	18.5	.....	85.1	14.9
Oberalden	30,487.5	25.7	.1	92.5	7.4
Unalder	17,312.5	23.8	1.8	76.5	21.7
Glarus	26,567.5	15.4	.....	92.6	7.4
Zug	12,922.5	21.6	.....	73.5	26.5
Freiburg	76,875.0	18.4	10.5	48.9	40.6
Lolothurn	73,010.0	36.9	3.2	76.3	20.6
Basel-Stadt	987.5	11.0	.....	44.3	55.7
Basel-Land	36,237.5	34.2	.....	76.9	23.1
Schaffhausen	29,055.0	39.5	16.3	70.0	13.7
Appenzell:					
Outer Rodes	14,617.5	22.4	1.5	22.5	76.0
Inner Rodes	8,310.0	20.9	1.2	34.8	64.0
St. Gallen	101,387.5	20.1	2.4	59.8	37.8
Graubunden	316,897.5	17.6	.2	89.4	10.4
Aargau	110,542.5	31.5	6.9	75.9	17.2
Thurgau	44,920.0	17.5	7.9	30.5	61.6
Tessin	151,427.5	21.5	.....	82.3	17.7
Waadt	187,642.5	23.1	12.4	59.0	28.6
Wallis	192,652.5	14.7	.....	94.3	5.7
Neuenburg	57,420.0	28.4	8.4	48.3	43.3
Genève	6,437.5	9.3	.....	7.6	92.4
Average percentage	.....	20.6	4.6	66.9	28.5

ANNUAL CUT.

Unfortunately, the latest statistics do not contain any figures for the forest cut, but the earlier statistics do contain such, and since there could not be any great change in the amount of cutting, these figures may serve our purpose.

In the early eighties the cutting, according to Professor Landolt,[a] in state forests amounted to 5,509,400 cubic feet, or 68 cubic feet per acre; in communal and corporation forests, 65,653,560 cubic feet, or 51 cubic feet per acre; and in private forests, 27,335,400 cubic feet, or 48 cubic feet per acre, making a total of 98,498,000 cubic feet, or an average of 51 cubic feet per acre.

Of the total cut, 40 per cent formed saw-log timber for building purposes.

ANNUAL GROWTH.

The cut of 51 cubic feet per acre, or a total of 98,498,000 cubic feet, may be taken as representing the annual growth of all the Swiss forests, since Switzerland has for a long time been practicing forestry and became converted to the principle of cutting only the annual increment, leaving the forest capital which produces that increment.

CONSUMPTION.

The comparatively large annual cut ought to be sufficient, apparently, for a population of about 3,000,000 inhabitants (in 1900 there

[a] A. Furrer. Volkswirtschafts der Schweiz.

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were 3,117,000); but as a matter of fact Switzerland is compelled to import timber from abroad, and the figures for imports and exports for the fifteen years following 1885 show that the imports are constantly growing while the exports are constantly decreasing. Timber is obtained chiefly from Germany, Austria, and France. By aid of the figures for exports and imports and the amount cut in the forests, the wood consumption, in cubic feet, for the period from 1895 to 1899 may be determined as follows:

	Saw-log timber.	Firewood.
Annual cut	40,000,000	60,000,000
Excess of imports over exports	8,500,000	8,500,000
Total	48,500,000	68,500,000

The total consumption is 117,000,000 cubic feet, or 38 cubic feet per inhabitant. Of this, 15.7 cubic feet are in the form of saw-log timber and timber for building purposes and 22.3 cubic feet in the form of firewood.

WOOD PRICES.

The stumpage prices of saw-log timber and construction timber at the place of cutting, 1895–1899, was 8.4 cents per cubic foot, and for firewood nearly 5 cents. The average price for both timber and firewood was 6.3 cents per cubic foot. These prices are practically the same as those in Prussia.

DENMARK.

FOREST AREA.

The forest area of Denmark in 1899 comprised 623,575 acres, or 6.3 per cent of the total land area, and a per capita of 0.25 acre. The islands Seeland, Bornholm, Laaland, Falstr, and Fyen, occupying 9.3 per cent of the total area of Denmark, contain 300,137.5 acres of forest land, or 49.7 per cent of the total forest area. The other half of the Danish forests, 328,437.5 acres, or 50.3 per cent, are found on the mainland (Jutland).

The state forests comprise 23.8 per cent, or 143,702.5 acres; of this area, 45.8 per cent is found on the Danish islands and 54.2 per cent on Jutland.

COMPOSITION.

Of the total forest area 266,515 acres, or 44.2 per cent, are beech forests; 90,622 acres, or 15 per cent, are other hard woods; 228,625 acres, or 37.9 per cent, are coniferous forest; and 17,812 acres, or 2.9 per cent, are scrub growth.

Of the total area of state forests, 42,197 acres, or 29.3 per cent, are hard-wood forests (chiefly beech); 49,917 acres, or 34.8 per cent, are coniferous forests; 41,822 acres are on barren land; and 9,767 acres, or 6.8 per cent, are not on true forest soil. The area of productive state forests is therefore only 92,114 acres. The large proportion of unproductive land in the state forests is due to the vast areas of

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heathland found on Jutland and the island of Bornholm. It is interesting that the coniferous forests of Denmark are all planted, the first conifers having been introduced at the end of the eighteenth century. On the island Bornholm is found even the silver fir.

ANNUAL CUT, GROWTH, AND CONSUMPTION.

Unfortunately, there are no figures regarding the cut and growth or any data concerning wood consumption. Denmark fully appreciates the value of forests and treats most carefully those few which she possesses, and tries to increase the area as far as possible by planting the waste lands. Unfortunately, the area of forests is very small and the production far too little for a population of 2,300,000 inhabitants. The total productive forest area is probably not over 575,000 acres. Assuming that the forests of Denmark are producing annually as much as the forests of Holland—that is, 45 cubic feet per acre—the annual production of wood in Denmark would be 25,875,000 cubic feet. In addition to this, Denmark imports about 22,951,500 cubic feet of structural timber, or a total of 48,826,500 cubic feet. With a population of 2,455,000 the wood consumption is 19.8 cubic feet per capita.

BULGARIA.

FOREST AREA.

The agricultural statistics for 1897 credit Bulgaria with 7,169,675 acres of forests, while the forest statistics give 7,602,815 acres, or 30 per cent of the total land area. Of this, 4,375,490 acres lie within 1,200 feet of sea level, 1,614,000 acres lie between 1,200 and 3,000 feet in elevation, and 1,613,325 acres at an altitude above 3,000 feet. Only 375,000 acres of the state forests are accurately measured.

The Balkan Mountains are the most heavily wooded, especially the eastern half. Northern Bulgaria, especially the Danube region, is most sparsely wooded. In Dobrucha, along the Black Sea, dried manure is used for fuel. The forest area per capita amounts to 2.4 acres, varying from 0.2 to 10.4 acres per capita in the different provinces. The State owns 29.6 per cent, communes 51.4 per cent, and private individuals 19 per cent of the total forest area. Until 1869 the cutting of timber and grazing in the state forests were entirely free; since that year they have been brought under regulation, though not without a great deal of friction between the Government and communities.

COMPOSITION.

Hard woods (oak, beech, and, in the south, walnut) predominate. Conifers occur only in the mountains.

Bulgaria may be truly called a rural country, since five-sevenths of the total population live in villages and are engaged in agriculture. There is no rational forest management, and practically nothing is known of the condition of the forests.

SERVIA.

Data regarding Servian forests are extremely conflicting. Thus Mélard [a] gives the extent of the forests of Servia at 5,225,000 acres, or

[a] Insuffisance des bois d'ouvre.

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42 per cent of the total land area. Kolm [a] gives the forest area as 4,500,000 acres; Keltie [b], as 1,202,500 acres; and Endres as 3,864,774 acres, or 32 per cent of the land area. Since the figures given by Endres [c] are more recent, his estimate is undoubtedly the most reliable. The forest area per capita may be taken then as 1.55 acres. According to ownership the forests are divided as follows: State forests, 1,417,230 acres, or 36.6 per cent of the land area; communal forests, 1,645,650 acres, or 42.6 per cent; church and monastery forests, 42,707 acres, or 1.1 per cent; and private forests, 759,187 acres, or 19.7 per cent, making a total of 3,864,774 acres, according to Endres.

The boundaries of the different forest owners are, however, very uncertain and still disputed. The eastern part of Servia is very little wooded. Hard woods (beech and oak) occur chiefly in the east and north, while conifers (fir, spruce, pines) are found in the west and south. On the whole, the broadleaf forests predominate. Every citizen has the right to cut timber for his own needs in the state forests; it must, however, be paid for if cut for sale. Under such a system of cutting there can hardly be any regular forest management. From the fact that in 1903 Servia had an excess of imports over exports amounting to 5,846,000 cubic feet it must be inferred either that the forests are not yet opened up or that they are already ruined by abuse, because with a forest area of 1.55 acres per capita and undeveloped industries, the forests should be fully able to supply the needs of home consumption.

No figures are available regarding the cut, yield, or consumption of wood.

GREECE.

FOREST AREA.

The forests of Greece occupy 2,023,380 acres, which is less than 13 per cent of the total land area. The forest area per inhabitant is 0.83 acre. Greece was once thickly wooded, and in ancient times had a large merchant marine and navy for that period. All the ships built were supplied with wood from the neighboring mountains. Because of her large merchant marine, supplied from her forests, and the great number of warships built from the timber grown in her own forests, Greece was able to extend her commerce throughout the Mediterranean and to maintain her independence.

Now the forests are gone or are being devastated rapidly. Reckless cutting, fires, and grazing will soon complete the destruction in a country where forests are greatly needed. Nine-tenths of Greece is mountainous. The rivers have a rapid fall and resemble torrents, drying out in summer, and causing floods and destruction in autumn and winter.

Information regarding forests and forestry is extremely meager. From the fact that agriculture is at a very low level, one may safely infer that forestry is in no better condition. The chief cause of such unwise use of the natural resources must be sought in the ignorance of the people. According to Keltie, 30 per cent of all recruits admitted to military service are entirely illiterate, and only 15 per cent can read.

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[a] Serbien; W. Kolm (Semlin, 1894).
[b] The Statesman's Yearbook; Scott Keltie (London, 1901).
[c] Handbuch der Forstpolitik; Endres (Berlin, 1905).

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Although industrially undeveloped, Greece has not enough wood to provide for home consumption. Annual imports amount to 275,387 cubic feet.

TURKEY.

It is impossible to obtain figures for a country which, like Turkey, does not officially recognize the value of statistics. The forest situation in Turkey is no better than in Greece. There may still be some remote corners of merchantable forest, but the country as a whole must be very poor in this respect. Here, as in Greece, the ravages of man and beast are equally severe, and in the few forests remaining the destruction exceeds production.

* * * * * * *

The countries so far considered are those whose natural resources have been more or less fully explored and whose forests yield large quantities of materials in common use, which can be delivered at a low price to market.

The forests of the rest of the world may be and are botanically rich in species, but do not have great commercial value because they lack the kinds of wood needed in commerce and industry by the 250,000,000 people composing the most advanced and powerful nations of Europe. The richest forests in Europe, commercially, are those of Sweden, and yet botanically they are very poor, containing but two principal species, Scotch pine and spruce. The forests of the regions which were not considered in the previous pages will now be discussed under continents; and since our knowledge concerning those forests is, in the majority of cases, very meager, they can be treated only in a general way.

ASIA.

The forests of British East India, Japan, Siberia, and Caucasus were mentioned before. The forests of the Philippines will be taken up in connection with those of the United States.

CHINA.

The forests of China are practically unknown. Undoubtedly there must be some forests, since wood is used for building homes, etc. In Manchuria, in the three eastern provinces of the Chinese Empire, there are apparently large forests, but nothing is known of their extent. The species of economic importance in Manchuria are birch, alder, oak, maple, elm, cork tree, poplar, ash, fir, spruce, pine, and willow. The forests must be sufficient for local needs. As to the western provinces of China, they need foreign timber and receive it from the United States and Canada.

The imports are not very great as yet, but have increased considerably compared with the imports of the sixties and seventies. From the United States and Canada, China receives principally saw timber. Eventually, when the country enters upon active construction of railroads, the demand for timber will increase enormously. With 380,000,000 people, when it becomes an industrially developed country, China will be a large buyer of wood in the world's market.

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PERSIA.

This country is almost treeless. Over the largest part of it trees grow only in parks surrounding cities. Only the Caspian provinces are rich in forests of all kinds. Here, on account of the fertility of the soil, abundance of moisture in the soil, and high temperature, vegetation is extremely luxuriant and dense. The whole northern slope of the Elburz Mountains, skirting the southern shore of the Caspian, is covered with forests. In this region many species are found—elm, oak, plane tree, cherry, plum, etc.; but the most valuable tree is the palm (*Buxus sempervirens*), from which is extracted a gum which is used by the people for chewing. It is considered very good for preserving the teeth and is a disinfectant. In Europe the *Buxus sempervirens* is used in engraving. This tree is now practically exterminated in all places where it was accessible, being now only found in the northwestern extremity of the Caspian region.

BRITISH POSSESSIONS IN ASIA.

CEYLON.

Next to East India, Ceylon is the most heavily wooded Asiatic possession of Great Britain. Its forest area is given as 6,762,880 acres, or 42 per cent of the total area of the island.

The number of species is very great, among which ebony and satinwood are the best known. In general the composition comes very close to that of British India; beside the species found in British India, the bamboo, eucalyptus, beech (*Fagus religiosa*), and a great number of others are found.

The local consumption of big timber is small. Although Ceylon exports rare woods, like ebony and satinwood, it needs timber for construction and has an excess of imports over exports.

The Ceylon climate is adapted to growing rubber trees, and this industry has been started on a large scale. At the close of 1900 there were 1,763 acres of all kinds of plantations.

THE FEDERATED MALAY STATES.

The total forest area of the Malay States is not known, except that the British Government has established several forest reserves with an aggregate area of 101,560 acres.

THE STRAITS SETTLEMENTS.

According to Mr. H. C. Heel, late inspector-general of the forests to the government of India, 88,320 acres, or 9 per cent of the total area of the Straits Settlements, have been declared reserved state forests. The colony exports a great deal of rubber, and the cultivation of rubber plants is a profitable enterprise.

CYPRUS.

The island of Cyprus, lying in the Mediterranean Sea in Asia Minor, is on the whole scantily wooded. An area of 448,000 acres is classed as forest, but many parts of this are of more or less open char-

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acter. The most common tree is maritime pine. There are also found *Pinus laricio*, several species of oak, plane tree, alder, cedar, cypress, juniper, elm, and walnut. *Rhus coriaria* (the sumac of commerce), carob, and olive flourish.

TERRITORIES OF THE BRITISH NORTH BORNEO AND SARAWAK.

The total forest area of Borneo and Sarawak is not known. The territories are rich in timber and other products of the forest, as gutta-percha and india rubber. The exports of timber exceed the imports in volume.

FRENCH POSSESSIONS IN ASIA.

The forests of the Indo-Chinese possessions of France and countries under its protectorate are large, but are very little known and very little used, although they include almost the same species as are found in the forests of British India.

DUTCH POSSESSIONS IN ASIA.

Large forest areas are found in the colonies of the Netherlands, on the islands of Java and Sumatra, and part of Borneo. The forests of Java are most known. They comprise 4,920,000 acres.

AUSTRALIA AND OCEANIA.

In Australia forests in the European sense are very seldom met with, except in the form of a few thousand acres of artificial plantations. The Australian forest exists either as thicket, open forest, or chapparral growth. The tree-forest region of the mainland is almost entirely along the coast. The areas under forest in the different colonies have been estimated as follows:

Area of forests by colonies.

Colony.	Area of forests.	Land area under forest.
	Acres.	*Per cent.*
Queensland	39,680,000	9.0
New South Wales	19,840,000	10.0
Victoria	11,520,000	20.0
South Australia	3,840,000	.7
West Australia	20,480,000	3.3
Tasmania	10,880,000	65.0
New Zealand	20,480,000	31.0
Total or average	126,720,000	19.8

The distribution of forests in Australasia, as may be seen from this table, is very different in the various colonies. Thus while in South Australia the forest does not occupy 1 per cent of the total land area, in Tasmania it forms more than half the total area.

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The mainland and Tasmania are the home of the eucalypts and wattles. New Zealand, especially in the northern island, is rich in conifers, of which the Kauri pine is the most valuable. The thicket forest of Australia, especially of the east coast, has a primeval character. The open forest contains chiefly hardwoods, especially the eucalypts, and the chaparral forests contain acacias.

Recently nearly all colonies have withdrawn smaller or larger areas as timber reserves, the exploitation and care of which is regulated by law. Thus in Queensland, of the 40,000,000 acres, 1,500,000 acres have been declared timber reserves; in New South Wales, of the 20,000,000 acres of timber lands, 6,000,000 acres have been withdrawn from settlement, but not in perpetuity; in South Australia, of the 3,840,000 acres, 217,000 acres were declared reserves under the forest law of 1882, but of this area only one-fifth contains timber of commercial value, the rest being stocked with stunted trees and scrub; in addition, there are 13,000 acres planted chiefly to sugar gum, pines, American ash, and other trees; in West Australia there are 20,480,000 acres of timber lands, and more than four times as much jungle covered with small trees and scrub.

In the following statement are shown the most important trees in West Australia, the areas which they cover, and the quantity of timber standing on them:

Area and stand of timber of principal species in West Australia.

Species.	Area of forests.	Total commercial timber.	Per acre
	Acres.	*Cubic feet.*	*Cubic feet*
Jarrah	8,000,000	2,000,000,000	250
Karri	1,200,000	750,000,000	625
Tuart	200,000	15,000,000	75
Other species	11,000,000	350,000,000	30
Total	20,400,000	3,115,000,000	150

No timber land has been placed in reserves. Tasmania, with 11,000,000 acres of forest, equal to 65 per cent of the total area of the island, has a reservation of 266,000 acres; it is, however, subject to revocation at any time by the governor.

The forest area of New Zealand is variously estimated at from 20,000,000 acres, or 31 per cent of the total area, to only 12,000,000 acres; by an act of 1885, 1,250,000 acres were declared timber reserves. In Victoria, of the 11,520,000 acres, 5,500,000 acres have been declared reserves under the act of 1890.

Thus the colonies of Australasia possess an area of nearly 15,000,000 acres, corresponding to the state forests of Europe. A great part of this area, however, may be reopened to settlement.

There are only fragmentary figures regarding the cut in the forests of the Australian colonies. The cutting is leased under a system of royalties or licensing fees. While West Australia, Tasmania, and Queensland have an excess of exports over imports, Victoria, New South Wales, and South Australia have an excess of imports over exports. For Australia, as a whole, the imports at present exceed the exports, and therefore it must be classed among the countries deficient in timber. The forest area of Australia ought to be suffi-

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cient to supply fully the local needs. New Zealand also, with its mild and moist climate and its great mountain chains and magnificent coniferous forests, resembling those of the northern hemisphere, onught to be able to supply large quantities of timber for export to her neighbors. Some statisticians, like Mélard, think that the forests of Australia have been devastated, and that a country which lives by sheep (in 1896 Australia possessed 89,745,000) can not raise at the same time both sheep and forests, as sheep require daily more extended grazing grounds at the expense of the forest. Others believe that the forests of Australia are not opened yet, and that eventually they will be fully able to supply enough good timber at least for home consumption. At present the deficit is covered by importations from the United States, Sweden, and Russia.

HAWAII.

The total area of native forests in Hawaii has recently been computed as 1,174,992 acres. In addition to this is the Algaroba forest of approximately 50,000 acres. There are established at present in Hawaii 16 forest preserves, comprising in all 444,116 acres.

The forests resources of Hawaii will be more fully discussed in connection with those of the United States.

AFRICA.

The forests of Africa are as yet very little explored. There is no doubt that in some parts of it there are to be found very valuable trees. The French and English colonies are best known.

FRENCH POSSESSIONS IN AFRICA.

ALGIERS.

In 1900 the forests of Algiers occupied an area of nearly 8,000,000 acres, a great portion of which is unproductive. The State owns 6,250,000 acres, or 77 per cent of the total; private individuals, 1,250,000 acres; and communes, 192,000 acres. Forests occupy in different parts of the country from 4 to 25 per cent of the total land area.

Botanically, the Algerian forests are very rich. The principal species are: Cork oak (1,025,000 acres), and pine (2,000,000 acres); other species cover 470,000 acres.

TUNIS AND OTHER COLONIES.

In Tunis the forests occupy 2,027,000 acres, nearly all in the northern part of the country. Like the Algerian forests, they are greatly devastated by fires and grazing. The productive area is probably not more than 1,630,000 acres. Of this the State owns 1,158,740 acres, or 77 per cent; the rest belongs to private individuals, societies, etc. The prevailing species is oak; cork oak occupies 290,000 acres; all other oaks, 117,500 acres.

The island of Madagascar has about 25,000,000 acres of forest, or 19 per cent of the total land area.

All other African possessions of France contain valuable species, but the extent of the forests is little known.

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BRITISH POSSESSIONS IN AFRICA.

SOUTH AFRICA.

The total forest area of South Africa in May, 1905, was 640,902 acres.[a] This area includes the whole of South Africa south of the Zambesi, with the exception of Rhodesia and Portuguese East Africa, for which data are wanting. While there is forest of some economic importance in the Portuguese territory and on the Rhodesian plateau, none of the regions have any appreciable area of dense forest comparable to that of Natal, Cape Colony, and Transvaal. This forest area is distributed as follows among the different colonies: Cape Colony, 529,902 acres; Natal, excluding scrub forest, 90,000 acres (old Natal, 40,000, and Zululand, 50,000); Swaziland, 1,000 acres; and Transvaal, 20,000 acres; making a total of 640,500 acres.

Deducting from this total area the very poorly stocked cedar forests, there remains 524,408 acres of yellow wood (*Podocarpus elongata* and *P. thunbergii*), the most valuable species of South Africa. Of this amount, 23,535 acres are artificial plantations. As may be seen from these figures, Cape Colony contains the largest amount of forest, which represents not quite 0.3 per cent of the total area of the colony. The forest area per inhabitant in 1901 was 0.22 of an acre, which is not sufficient to supply the needs of the people.

Very little definite information exists in regard to the forest areas in the other British possessions in Africa, such as the west coast of Africa, the East Africa Protectorate, Uganda Protectorate, Central Africa Protectorate, the Soudan and Mauritius, beyond the amounts of exports of rubber and gums. One thing is certain, and that is that they do not contain sufficient timber to supply their own needs.

Mélard divides Africa, in accordance with the distribution of rainfall, into four zones, parallel to the equator: the Atlas and Mediterranean slopes; the Sahara; the equatorial zone; and the South Africa zone.

The Atlas and Mediterranean slopes comprise Tunis and Algeria and the other French colonies, the forest resources of which have been discussed above. The South African zone includes the British and Portugese possessions, the forest resources of which have also been discussed. There remains now to say a few words about the Sahara and the Equatorial zones.

The Sahara, with the exception of small oases where palms are cultivated, has no forests. Egypt belongs to the Sahara zone; it has no forests, and its demand for timber is constantly increasing as a result of the growing industries and the extension of railroads.

The Equatorial zone is supposed to contain virgin forests able to replace Canada and Sweden in the market. Mélard shows that the Equatorial forest is much less rich and extensive than has been thought. Near the Gulf of Guinea, between 10° N. and 4° S., there is a wooded area which is estimated at from 45 to 60 miles wide. East of this zone are found savannas, covered for hundreds of miles with coarse grass and scrub growth. Such is the Soudan, the

[a] Forests in South Africa, D. E. Hutchins, Capetown, South Africa; from Science in South Africa, August, 1905.

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French, and the Belgian Kongo as far east as the upper basin of the Kongo River and its tributaries, where another large forest area is found. The Equatorial zone thus consists of two great forests, one along the western coast of Guinea and the other in the center on the upper basin of the Kongo River, divided by a vast treeless area. No definite information exists about these tropical forests of Central Africa beyond the fact that they contain many precious cabinet woods, dyewoods, etc.

CENTRAL AND SOUTH AMERICA.

MEXICO.

FOREST AREA.

The area of the forests of Mexico is estimated at from 20,000,000 to 25,000,000 acres of commercially valuable timber, or 5.1 per cent of the land area. The forest area per capita is 1.8 acres. The bulk of the forests apparently belongs to the Government, which works the forests on a system of leases.

COMPOSITION.

The forests of Mexico are of two distinct kinds: The tropical forests along the coast of the Gulf of Mexico, composed of mahogany, Spanish cedar, rosewood, and other fancy woods, and the pine and oak forests of the mountains, principally in the Sierra Madre on the Pacific side of the Mexican plateau.

Of these two types, the pine forest is by far the more important from the standpoint of the timber trade. These forests are very inaccessible, however, and little is known about the character of the timber, though some idea can be gained from the fact that a tract of 1,000,000 acres, recently sold, was estimated to have a stand of 8,000 board feet per acre, composed two-thirds of pine and one-third of oak. This is probably somewhat above the average for the whole area of pine forest.

The species found in the pine forests are known as white, sugar, and yellow pines, red and white firs, and many species of red and white oaks.

ANNUAL CUT, GROWTH, AND CONSUMPTION.

The forest resources of Mexico have been very little developed as yet; the pine timber is very inaccessible and the tropical hardwood forests have been worked only to a limited extent for mahogany and cedar. Figures on the growth of the forests and the wood consumption are lacking. The annual cut of timber is given at 225,000,000 board feet of manufactured stock, or approximately 37,500,000 cubic feet of logs; and it is estimated that Mexico imports 70 per cent of its timber consumption. Assuming that this is correct, the home consumption of manufactured stock, including ties, would be 125,000,000 cubic feet, or 9 cubic feet per capita. This low consumption is due to the still undeveloped resources of the country. Whether Mexico will be able to supply its own needs of timber is

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questionable. At present its imports are more than three times what is cut at home. Ninety-nine per cent of all the imports come from the United States.

WOOD PRICES.

The stumpage price for pine, in the remotest and least accessible portions of the country, is as low as 75 cents per thousand feet. Standard-gage pine ties sell at 45 cents and oak ties at 57 cents apiece delivered at the railroad. Green lumber from the saw is sold at from $17.50 to $32.50 per thousand feet b. m.

Mahogany and cedar logs shipped from Gulf of Mexico points f. o. b. New York command the following prices: Laguna cedar (*Cedrella odorata*), $45 to $60 per thousand board feet; Laguna mahogany (*Swietinia mahagani*), $40 to $55; cedar from other points, $32.50 to $57.50; mahogany from other points, $30 to $50.

CENTRAL AMERICA.

The five Central American Republics possess extensive forest areas, which, however, are so little explored that there are no data as to their extent or volume. In countries which do not know even the size of their population it is unreasonable to expect any knowledge of their forests. The reason for the existence of large forest areas in Central America is not due in any way to the care of them by the people, but to the fact chiefly that they are inaccessible on account of lack of roads or any other means of transportation.

SOUTH AMERICA.

According to Semler,[a] South America has an enormous forest wealth. With the exception of the prairies of Uruguay and Argentina, most of the continent is covered with forests. The whole chain of the Andes Mountains is wooded, the forests, according to altitude, latitude, and exposure, being of different composition. The cutting has not as yet impaired their value, because, first, the countries of South America are still very thinly settled; and second, which is more important, there are comparatively few rivers suitable for transporting timber to the coast. Not a single State has made any forest survey or has any clear idea of its forest resources.

The eastern coast of South America, south of Rio de la Plata to the Straits of Magellan, is extremely sparsely wooded. Only here and there are found a few thorny acacias, and along the rivers individual groups of willows, and occasionally antarctic beech, forms larger stands. In remarkable contrast to these are the islands of Tierra del Fuego, which, according to Darwin, are completely covered with forest.

North of the Rio de la Plata in Uruguay one finds small forests along the rivers, which have no commercial value, but which supply the needs of the few people who live there.

An entirely different picture is presented in Paraguay, whose slopes toward the Parana River are covered with almost impene-

[a] Tropische und Nordamerikanische. Waldwirtschaft und Holkunde—Heinrich Semler, Berlin, 1888.

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trable forests. On the slopes toward the Paraguay River are the settlements; here is open grass land, and only the hills, as a rule, are wooded. According to a statement, which, however, needs confirmation, there are seventy kinds of woods which are commercially useful, two of which, lapacho and quebracho, were used by the Jesuits in constructing their missions and are still well preserved in the ruins. Fifteen kinds of trees yield dyewoods, and eight yield fibers.

The forests of Brazil cover an area equal to one-half of Europe. The Amazon flows for a distance of 1,860 miles through a virgin forest which stretches 1,100 miles from east to west and 750 miles from north to south, and occupies an area of 825,000 square miles. Many of the Brazilian woods have excellent properties. The following are among the most valuable: Pernambuco (*Cæsalpinia echinata*), fustic (*Macluria tinctoria*), both of which occur only near the coast; Jacaranda, ironwood (*Cæsalpinia ferrea*), and cedar (*Cedrela brasiliensis*). The forests yield other valuable products, as rubber, Brazil nuts, Paraguay tea, guarana, gums, and resins.

Guiana is relatively just as rich in forests as Brazil, especially British Guiana, which has the advantage of four large rivers which, with their tributaries, are very suitable for floating logs. For this reason the exploitation of these forests has advanced further than in any other part of the country. British Guiana furnishes two of the most valuable trees for shipbuilding—greenheart (*Nectandra rodœi*) and mora (*Mora excelsa*). Greenheart is the more important, and is so hard that it nicks the axes of choppers and will last for over one hundred years in water. Dutch Guiana has a very important wood in the purpleheart (*Copaifera bracteata*), which is suitable for the use of wheelwrights. French Guiana has a very important wood, so-called violet wood (Bois violette—*Copaifera bracteata*), which is especially suited for woodworking.

Venezuela is for the most part a prairie. Its most extensive forests are found on the lower course of the Oronoco River. The home production hardly exceeds the home consumption, the only wood that is exported being *Zygophillum arborea*.

Colombia, though partially a prairie State, possesses more forests than Venezuela. The exports, however, are insignificant because of lack of transportation facilities. Ecuador and Peru are in the mountain region of the Andes, and have exceptionally luxurious and extensive forests, which are, however, entirely inaccessible. Both of them import wood from North America.

The northern part of Chile has no forests. Forests are found only in the south, beginning at San Jago, especially in the provinces of Arauco, Valdivia, and Chiloé, but are rapidly disappearing, not on account of any great drain upon them for home consumption or export, but because the land is needed for agriculture. The forests are burned and treated by the people as an enemy, as was the case in this country at the time of the earliest colonization.

While at present South America imports some timber, it is hardly to be expected that these imports will greatly increase in the future. On the contrary, they will probably decrease, as the forests become opened up and are made more accessible.

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WEST INDIES.

Semler takes a very gloomy view of forest conditions in the West Indies. He thinks that on the whole the West Indies present a sad picture of forest destruction. The small islands are robbed of their former forest wealth; and the large ones, like Jamaica, San Domingo, and Cuba, have only remnants. What little is left is almost entirely in the hands of private individuals, and nothing is done for the preservation of the forests.

John T. Rea,[a] who lived for four years in the West Indies, takes a more optimistic view of the situation, and since his observations are more recent and many of them are original they are apparently more trustworthy than Semler's. According to Rea's statement, two-thirds of most of the West Indian islands are still in virgin brush and forest, which are capable of yielding a plentiful supply of good material. Thus the Layon and Sara flats, or crown lands of Dominica, have an area of 40 square miles, and contain a mine of wealth in timber. In Trinidad, he estimates that there are at least 300,000 acres of forest land.

The total area of the West Indies is about 100,000 square miles. The trees on the whole are not very large, and yield as a rule only small scantlings. Some of the woods are useful for building and engineering work, but they are valuable principally for furniture, paneling, cabinet, and other fancy work. The immense variety of small articles, such as knife handles, knobs, buttons, etc., which are now manufactured from choice grained woods, opens a ready market for many West Indian timbers, the beauty of which can not be surpassed. Gum and resin yielding trees abound, and commercially valuable fibers may be stripped from quite a number of them. The bark, leaves, and berries of others furnish well-known drugs, dyes, and spices. Owing to the fact that all the best timber is in the inland forests with few convenient rivers for floating it down, and owing also to the defective character of the means of communication and the absence of sawmills and machinery for their treatment, the native woods have until lately been available only in small quantities. Circular and other rapid saws have been added to the plant of most of the public work yards, so that some of the disabilities have been remedied.

Little definite information is to be had concerning the forest area of Cuba. It probably does not exceed 5,000,000 or 6,000,000 acres, which, with a population of 2,050,000, makes the area per capita about 3 acres, and constitutes about 20 per cent of the total land area. Such an area with the small local demand for wood, if the forests are properly managed and cared for, certainly ought to furnish a sufficient supply for home consumption. Unfortunately, however, the forests do not contain the kinds of timber needed for most purposes, and hence large quantities are imported annually.

FOREST RESOURCES OF THE UNITED STATES AND HOW THEY COMPARE WITH THOSE OF OTHER COUNTRIES.

A detailed discussion of the forest resources of the United States is taken up under several other topics in the report to the commis-

[a] The Indian Forester, Dec., 1902, p. 44a, "West Indian Timbers."

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sion. Here it is intended merely to compare the most important features of the forest resources of this country with those of other countries. This, perhaps, will serve at the same time as a summary of the statistical facts brought out in the preceding pages.

FOREST AREA.

The United States occupies the second place among the nations of the world as to the extent of its forests; Russia, European and Asiatic, comes first; Canada stands third.

The forests of the United States, according to ownership, may be roughly divided as follows: National forests, 100,000,000 acres, or 18.35 per cent; state forests, 3,000,000 acres, or 0.55 per cent; and private and unreserved public forests (unclassified), 442,000,000 acres, or 81.1 per cent.

The bulk of the forests is either in private hands or likely to pass into private ownership.

While government and state ownership of forests has invariably proved the most advantageous form, yet the proportion of forest land owned or controlled by the State can not always be taken as a criterion of the state of development of forestry in the country. The Government may, for historic or economic reasons, have only a small area of its own, but still exercise a great influence over the forests of other owners. Thus, Austria has only 10.7 per cent of the total forest area under state ownership, Switzerland 4.6 per cent, France 12 per cent, and yet forestry in those countries is at a high state of development, as all other forests are under direct control of the State, which practically amounts to management by the State.

Government and state forests comprise about 19 per cent of all forests; since the bulk of the forests is in private hands and entirely outside of state supervision, the area which is assured of a proper and careful management is comparatively small. Below is given a comparative table of forests under state ownership in the different countries of the world:

Percentage of forests under state ownership.

Country.	Per cent.	Country.	Per cent.
Great Britain	2.2	Norway	28.5
Italy	4.0	Bulgaria	29.6
Switzerland	4.6	German Empire	31.9
Belgium	4.8	Sweden	36.5
Portugal	8.0	Servia	36.6
Austria	10.7	Roumania	40.0
Croatia and Slavonia	11.0	Finland	61.2
France	12.0	European Russia	69.0
Hungary	15.0	Bosnia and Herzegovina	78.6
Denmark	23.8	Spain	84.0
United States (National and State)	18.9		

To supplement this table, it may be added that in the German Empire 66 per cent of the total forest area is under state control. In Austria, Hungary, France, Switzerland, Italy, Sweden, and Denmark the private forests are under state control; and for this reason

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the forest area under state supervision is much larger than the figures in the above table would indicate.

The forests of the United States form less than 29 per cent of the entire land area. The following table gives the forest area and percentage of the entire land area under forests, by States and Territories. The forest area per inhabitant is about 8 acres, corresponding closely to that in Sweden and Norway.

Forest area of the United States, by States and Territories, 1908.

State or Territory.	Land area (acres).	Forest area.	
		Acres.	Percentage of land area.
Alabama	32,818,560	20,000,000	61
Arizona	72,857,600	14,000,000	19
Arkansas	33,616,000	24,200,000	72
California	99,898,880	24,000,000	24
Colorado	66,341,120	12,000,000	18
Connecticut	3,084,800	1,600,000	52
Delaware	1,257,600	350,000	28
Florida	35,111,040	20,000,000	57
Georgia	37,584,000	22,300,000	59
Idaho	53,618,560	20,000,000	37
Illinois	35,841,280	2,500,000	7
Indiana	22,966,400	4,000,000	17
Iowa	35,575,040	2,500,000	7
Kansas	52,335,360	1,000,000	2
Kentucky	27,715,840	10,080,000	39
Louisiana	29,061,760	16,500,000	57
Maine	19,132,800	14,900,000	78
Maryland	6,362,240	2,200,000	35
Massachusetts	5,144,960	2,000,000	39
Michigan	36,787,200	15,500,000	42
Minnesota	51,749,120	15,500,000	30
Mississippi	29,671,680	17,500,000	59
Missouri	43,985,280	18,300,000	42
Montana	93,296,640	18,000,000	19
Nebraska	49,157,120	800,000	2
Nevada	70,285,440	5,000,000	7
New Hampshire	5,779,840	3,500,000	61
New Jersey	4,808,960	2,000,000	42
New Mexico	78,401,920	12,000,000	15
New York	30,498,560	12,000,000	39
North Carolina	31,193,600	19,600,000	63
North Dakota	44,917,120	600,000	1
Ohio	26,073,600	4,800,000	18
Oklahoma	44,424,960	8,000,000	18
Oregon	61,188,480	27,000,000	44
Pennsylvania	28,692,480	9,200,000	32
Rhode Island	682,880	250,000	37
South Carolina	19,516,800	12,000,000	61
South Dakota	49,195,520	1,200,000	2
Tennessee	26,679,680	15,000,000	56
Texas	167,934,720	30,000,000	18
Utah	52,597,760	6,000,000	11
Vermont	5,839,360	2,500,000	43
Virginia	25,767,680	14,000,000	54
Washington	42,775,040	25,000,000	58
West Virginia	15,374,080	9,100,000	59
Wisconsin	35,363,840	16,000,000	45
Wyoming	62,460,160	10,000,000	16
Total	1,903,423,360	544,400,000	29

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COMPOSITION.

The species which are most valued in international trade are the conifers, such as pine, spruce, hemlock, fir, and larch. Coniferous forests, on the whole, as German experience has shown, produce a larger percentage of structural timber than hard woods. In Germany, therefore, there is a tendency to increase the area under conifers at the expense of that under hard woods. This tendency is also often prompted by necessity. Hard woods, as a rule, require better soil than conifers, and in countries where there is need for more agricultural land to provide for an increasing population, the forests are more and more relegated to the poorer soils where conifers can be grown to better advantage than hard woods. The forest wealth of a country is therefore determined not only by the extent of the forest, but also by the species that make up the forest. As has already been pointed out, the richest forest, from a commercial standpoint, is that of Sweden, which consists chiefly of but two species, pine and spruce. In this country, as a result of the reckless cutting of conifers, especially in the northeastern States, and of repeated fires, thousands of acres of coniferous forests in New England have been converted into poor hard-wood forests. In the Catskills one finds thousands of acres originally covered by hemlock now under scrubby hard woods, and the same is true in Maine and New Hampshire. If the soil is at all suited to hard woods, they are favored in reckless cutting and burning because of their sprouting capacity. Thus, while Germany has increased its area of coniferous forests, the area of hard-wood forests in this country has probably increased at the expense of the coniferous forest area. Below are given the countries and the predominance of either hard woods or coniferous forests:

Distribution of hard woods and conifers, by countries.

Hard woods predominate.	Conifers predominate.	Hard woods predominate.	Conifers predominate.
Australia and Oceania.	Russia.	Spain.	Germany.
British India.	Finland.	Portugal.	Austria.
Hungary.	Canada.	Italy.	Switzerland.
Croatia and Slavonia.	United States.	British Isles.	
France.	Sweden.	Holland.	
Japan.	Norway.	Denmark.	

It is hard to tell what proportion of the total forest area of the United States is under hard woods. From the rather conflicting estimates of the present stand of conifers and hard woods it would seem that the proportion of conifers to hard woods by volume is about 4 to 1 (on the basis of Doctor Fernow's estimate of 2,000,000,000,000 feet b. m. of both kinds, and the estimate of 400,000,000 feet b. m. of hard woods by the American Lumberman).

Of all the countries of the world the United States is the only one which has such a variety of conditions as to favor the growth of a great number of valuable species, both conifers and hard woods, over large areas.

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PRESENT STAND.

The latest and best estimate of the stumpage of the United States places it at 2,500,000,000,000 feet b. m. This, however, does not represent the forest capital in the sense in which does the estimate of 944,700,000,000 board feet of the German Empire. In Germany the estimated stand is a constant quantity, a capital, which is capable of producing annually some 50 cubic feet per acre. In this country the stumpage represents a capital which is annually drawn upon, since the cut does not represent the annual growth but exceeds it. With an annual cut of about 23,000,000,000 cubic feet of standing timber and a forest area of about 545,000,000 acres, the cut per acre is 42 cubic feet, while the annual growth on the area has been estimated at 12 cubic feet per acre.

The United States is not the only country which at present cuts more than is annually produced. The different countries may be divided according to whether they cut more than the forest produces, less, or just the same amount. In the following table are brought together the data available from the different countries of the world concerning the annual cut and the annual growth per acre.

Annual cut and annual growth per acre, in cubic feet, for various countries.

	Annual growth.	Annual cut.		Annual growth.	Annual cut.
Countries which overcut.			France	37.9	37.90
			Switzerland	51.0	51.00
Austria	42.4	60–67	United Kingdom	45.5	45.50
Hungary	44.4	30–33 53.00	Belgium	758.2	758.20
Croatia-Slavonia	43.4	30–33	Holland	46.0	46.00
Canada	20.0	[a]17.00	Denmark		
Norway	11.3		Italy	37.3	37.30
Roumania [b]					
Spain [b]			*Countries which cut less than the growth.*		
Portugal [b]					
Greece [b]			Russia	31.0	17.00
Turkey [b]			Finland	19.8	[c]3.44 [d]20.00 13.60
Bulgaria [b]					
United States	12.0	42.00	Sweden	25.0	19.10
			British India		3.00
Countries which cut just the annual growth.			Japan		35.00
			Servia		
Germany	48.7	48.70			

[a] Plus great fire loss, estimated at 170 cubic feet per acre.
[b] No definite figures on these countries, but facts indicate that they are being overcut.
[c] State forests, 38.7 per cent.
[d] Private forests, 61.3 per cent.

While in a general way these figures indicate the annual cut and growth in the different countries, yet they do not tell the whole story. They represent the total amount of wood cut and produced, irrespective of kind.

In most of the countries where at present the forests are being overcut, and they are the countries which still contain virgin timber, the proportion of structural timber to firewood in the cut is much greater than will be the case in the second growth. The figures would indicate that out of 23,000,000,000 cubic feet of wood cut annually to supply the forest products, 9,000,000,000 feet (allowing 90 cubic feet per cord), or 39 per cent, is firewood. This percentage of firewood appears to us too high, but if it is correct, then the proportion of saw-log timber in the second cut will certainly be less than

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half of the total amount of wood produced annually, because the forests under the present system of cutting do not improve, but deteriorate in quality. This holds true not only of the United States, but of Canada, Austria, and Norway, while the reverse is true of countries like Germany and France, where the percentage of saw-log timber is gradually increasing through proper methods of management.

The cut per acre in such countries as Canada, the United States, and Russia does not represent the actual cut per acre, because these figures do not always refer to the actual productive forest area, but include a great deal of unproductive land, such as swamps, burns, etc. If the figures referred only to the productive-forest area, if that could be known, the cut per acre would be much higher.

On the whole, the figures of annual cut and growth show a sad state of affairs. Countries which with proper care for their forest resources could continue to be a source of timber supply to many other countries deficient in wood are, with a few exceptions, overcutting their forests and rapidly deteriorating them, and in those few countries with large forests which do not overcut the resources are deterred only through want of capital or lack of natural means of transportation, such as rivers, etc. On the other hand, some other countries, though they have not enough forests to supply their own needs, continue to deplete what little they possess.

From the figures of annual growth and cut in the United States it would appear that the cut is more than three times the growth. In point of fact, however, the depletion of our forests goes on much more rapidly, owing to loss by fire on account of the lack of protection given the forests.

ANNUAL CONSUMPTION.

The consumption of wood is different in different countries, being dependent on the industrial development, on the presence of coal for fuel, and of substitutes for structural timber. In the following table are brought together the total annual consumption and the consumption per capita in the various countries of the world:

Annual and per capita consumption, in cubic feet, of various countries.

Country.	Total annual consumption.	Consumption per capita.		
		Total.	Timber.	Firewood
United States	23,000,000,000	260.0	160.0	100.0
Canada	1,111,209,625	192.0	60.0	132.0
Norway	276,000,000	125.0	.....	.....
Sweden	404,000,000	120.0	.....	.....
Finland	237,000,000	91.5	.....	.....
Russian Empire (exclusive of Finland)	6,576,280,000	63.0	25.0	38.0
Austria-Hungary	2,500,000,000	57.0	28.5	28.5
Switzerland	117,000,000	38.0	15.7	22.3
Germany	2,064,122,300	36.6	18.8	17.8
Japan	.....	30.0	.....	.....
France	954,640,000	24.6	6.9	17.7
Denmark	48,826,500	19.8	.....	.....
Belgium	119,604,126	17.7	10.8	6.9
United Kingdom	670,890,000	14.0	12.8	1.3
Holland	67,200,000	13.1	10.3	2.8
Italy	405,548,000	13.0	2.5	10.5
British India	236,611,600	.8+	.....	.....

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Thus the home consumption of the United States is larger than that of any other country in the world. While the exports amount to 2,600,000,000 feet b. m., the imports in 1907 were 1,700,000,000 feet b. m., or an excess of exports over imports of only 900,000,000 feet b. m., or 150,000,000 cubic feet, a practically insignificant amount. Therefore, the annual cut of 23,000,000,000 cubic feet may be taken as the home consumption of the United States.

WOOD PRICES.

There is a certain relationship between the wood prices of a country and the care which the forests receive. In countries with large forests and sparse population, wood prices are low and there is very little forest protection. In the following table are given wood prices on the stump for some leading European countries and for the United States.

Wood prices on stump in various countries.

Species.	Price of structural timber per cubic foot.			
	United States, 1907.	Prussia, 1902.	Wurttemberg.	Hungary, 1901.
Oak	$0.04	$0.14	$0.25	$0.038–$0.11
Beech	.02	.084	.....	.087
Spruce[a]	.033	.096	.....	.....
White pine[b]	.05	.078	.13	.034– .067

Species.	Price of cordwood per cord.			
	United States, 1907.	Prussia, 1902.	Wurttemberg.	Hungary, 1901.
Oak	$1.00	$4.68	.....	$0.60–$3.20
Beech	1.00	4.68	$8.28	1.31– 2.60
Spruce	.....	2.97	.....	.....
Pine	.75	3.33	6.12	.....

[a] Eastern spruce only. [b] Eastern white pine.

These figures simply give an idea of the relative value of wood in different countries. A comparison of wood prices is extremely difficult, because prices do not always include the same items. In some countries the prices include transportation to points of shipment, in others they refer to partly finished products, etc. The few figures given in the above table all refer to the price on the stump. The stumpage prices for the United States are taken from Bulletin 77, page 40, Forest Service, and 167 cubic feet are assumed to equal 1,000 board feet. The prices in the United States are mainly those in the East, and are probably higher than if western species were chosen. As it is, oak timber, probably much poorer in quality than the white oak in this country, brings in Prussia over three times as much on the stump, and in Wurttemberg over six times as much as here. The same holds true for other species, except white pine, which in New Hampshire and the Northeast is at present bringing prices approach-

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ing those obtained by Scotch pine in Prussia and Hungary. In Wurttemberg, however, Scotch pine brings close to three times as much as white pine in this country. The prices for cord wood in European countries are also much higher than in this country. We excluded cord wood of spruce and pine in this country, since they are used for pulp, and it would not be fair to compare them with wood used for firewood in other countries.

The difference in the wood prices here and in European countries is very great indeed, but still they do not show the actual difference in the value obtained from timber in this and other countries. These figures refer only to the used part, which is much greater in Europe than here, and therefore the difference between the stumpage value per tree obtained in this country and abroad must be still greater.

Part II.—HOW FAR CAN WE COUNT ON FOREIGN SOURCES OF SUPPLY?

SUMMARY.

It is obvious that if the forest resources of the United States fail we must increase our imports of wood from other countries. It is equally obvious that if the net imports of the present wood-importing countries are increased, they will compete with the United States for wood from other countries. This will necessitate a still greater output of timber from wood-exporting countries. With these considerations in mind concerning the timber trade of the principal wood-producing and wood-using countries of the world, we reach the following conclusions:

EUROPE.

Europe both imports and exports more than one billion cubic feet of wood yearly. The imports, however, exceed the exports by about 10 per cent, the excess being made up chiefly by supplies from Canada and the United States. A brief summary of European conditions is as follows:

First. The leading import countries—that is, Great Britain, Germany, France, Belgium, Switzerland, etc., are rapidly increasing the amount of their imports, and this increase is certain to continue.

Second. Russia, Finland, and Sweden only of the export countries have increased their exports to great extent without encroaching on their timber capital.

Third. Norway and Austria-Hungary are already overcutting their forests and will in all probability have to reduce their exports in the future.

In view of these facts and considering the rising prices of wood throughout the world, it is certain that any increase of wood exports from Russia, Finland, and Sweden will be eagerly competed for by Great Britain, France, and Germany, and also that there will be no surplus of any consequence for the United States, which is handicapped by its greater distance from the principal source of supply.

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AFRICA.

Both north and south Africa are importers of timber and these imports will increase with the increased development of the country. The forests of central Africa are little known, but it is certain that their area is not so great as was once commonly supposed. The chief species of commercial value in that section are hard woods, which are expensive, and which have little bearing on the question of the supply of common timber for use in the United States.

ASIA.

India, the chief forest country of Asia, exports teak and some other valuable woods, but it is necessary for it to import structural timber. China is a wood-importing country, and its requirements will undoubtedly take the most of any surplus that may come from eastern Siberia and Manchuria. If only structural timber is considered, Japan is a wood-importing country, but if all woods are considered, it is a wood-exporting country. Japan can supply its own needs when all the forests become accessible, but will probably not be able to export any saw-log timber.

AUSTRALASIA.

Australia is a wood-importing country at present, and it is not likely that there will ever be much surplus timber for export. With the exception of comparatively small quantities of hard woods, the forests of Hawaii can never become important in the timber trade of the world. The Philippines at present import much more timber than is exported. Eventually the native forests should supply the principal demands of the home market with a considerable excess for exportation to near-by countries, such as China. The total stand of commercial timber in the Philippines, however, is no greater than the amount of timber annually cut for lumber in the United States. Hence the islands will never become an important factor in supplying our needs for wood.

TROPICAL AND SOUTH AMERICA.

Mexico, the West Indies, and Central America now import timber, not so much because they have none, but for the reason that their stands are at present inaccessible. It is probable that they will for some time continue to import the common structural timbers and will export valuable woods, such as mahogany and cedar.

For many years South America will continue to export hard wood, dye wood, etc., and to import lumber and construction material. When the great forests of the Andes and the interior are opened up then they will supply the home market. Wood consumption will have so increased in South America by that time, however, and logging and transportation will be so expensive because of the comparative inaccessibility of the forests, that it is not reasonable to expect any considerable exportation of timber suitable for common uses in the United States.

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NORTH AMERICA.

The total stand of timber in Alaska is probably no greater than twice the amount of lumber annually cut in the United States. The Alaskan industries require a considerable proportion of the output of the home forests, so little will remain for export to the United States.

Canada is the only country from which the United States is importing any considerable amount of timber. The total amount of standing timber in Canada, however, is estimated at no more than one-quarter of that in the United States. The Canadian forests are probably being cut and burned faster than they are growing, and this, with the rapid development of the Canadian provinces, will require all that the forests will eventually produce.

CONCLUSIONS.

A review of the timber trade of the various timber countries of the world shows a steady increase in the wood consumption and imports of nearly all of the leading countries, and but three important countries, Russia, Finland, and Sweden, can increase their exports without reducing their forest capital. This increase will be needed in western Europe to make up the growing deficit there and will not be a source of supply for the United States.

The tendency is toward a greater cutting of timber by the wood-exporting countries to make up the increasing deficit of the wood-importing countries. This policy, if continued, would lead to a universal shortage with no surplus to draw upon. There is no doubt, however, that there is enough accessible actual and potential forest land in the civilized countries of the world to produce, under proper management, an abundance of timber to supply indefinitely the world's growing demand.

This country must, so far as possible, depend upon itself. A considerable proportion of the present forest area of the United States will undoubtedly be cleared for agriculture as the population increases. The area of land in the United States so situated as to be permanent forest land is about 400,000,000 acres. The inevitable increase in wood consumption, following the increase in population and growth of industries, will thus have to be supplied from the diminished forest area. This means that the land should be surveyed and classified by the Government as permanent forest land before it is too late.

INTRODUCTION.

After the above-detailed discussion of the forest resources of the various countries of the world, the question naturally arises, How far, in case our own resources fail, can we count on foreign sources of supply? It is obvious that there must be an increase in exports of some countries, in event of a failure of our timber supply, to make up our deficiency. It is equally evident that if the amount of net imports of present importing countries should increase, they would compete with the United States in case it should run short, and

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thus necessitate a still greater output of timber by the exporting countries.

It is important, therefore, to trace the tendencies of the timber trade of the various countries for the last few years to see what deductions can be drawn as to the future, bearing in mind their resources, as brought out in Part I, and trying to bring out the reason why they import or export. The following table [a] shows the amount of net exports or imports of the important countries of the world:

Net exports and imports of various countries, yearly average, 1897–1901.

Country.	Net exports.		Net imports.	
	Cubic feet.	Feet board measure. [a]	Cubic feet.	Feet board measure. [a]
Russia (with Finland)	295,000,000	2,360,000,000		
Sweden	223,000,000	1,784,000,000		
Austria-Hungary	183,500,000	1,460,000,000		
Canada	107,200,000	857,600,000		
Norway	52,000,000	416,000,000		
United States	51,000,000	408,000,000		
Roumania	3,000,000	24,000,000		
India	2,750,000	22,000,000		
West coast of Africa	1,300,000	10,400,000		
West Indies, Mexico, Central America	650,000	5,200,000		
Alaska			170,000	1,360,000
Japan [b]			250,000	2,000,000
Ceylon			500,000	4,000,000
Servia			750,000	6,000,000
Mauritius			1,000,000	8,000,000
Greece			1,750,000	14,000,000
Philippine Islands			2,000,000	16,000,000
Bulgaria			2,500,000	20,000,000
China			2,500,000	20,000,000
Natal			2,500,000	20,000,000
Portugal			3,000,000	24,000,000
Cape of Good Hope			7,500,000	60,000,000
Australia			8,000,000	64,000,000
Switzerland			8,500,000	68,000,000
Holland			9,000,000	72,000,000
Egypt			10,000,000	80,000,000
Spain			10,500,000	84,000,000
South America			16,500,000	132,000,000
Italy			21,000,000	168,000,000
Denmark			23,500,000	188,000,000
Belgium			51,000,000	408,000,000
France			61,500,000	492,000,000
Germany			230,000,000	1,840,000,000
British Isles			464,500,000	3,716,000,000

[a] Since the figures include lumber, logs, poles, and split wood, 1 cubic foot was regarded as equivalent to 8 board feet. In the original conversion from tons, 1 ton is regarded as equivalent to 50 cubic feet.

[b] Schlich includes only construction timber; judged by value. Japan is an exporting country.

The relation between forest area per capita and export or import of timber can be seen from the following table: [b]

It will be noticed that countries with 92 or more acres per 100 inhabitants have a surplus of exports over imports, while those with 85 acres or less have a surplus of imports over exports.

[a] Schlich: The Outlook of the World's Timber Supply.

[b] Zon: The Future Use of Land in the United States.

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Relation between forest area per 100 inhabitants and exports and imports of the different countries.

Country.	Forest land per 100 inhabitants.	Excess of exports over imports.[a]	Excess of imports over exports.[b]
Exporting countries.	*Acres.*		
Canada	2,490	$26,551,000	.....
Finland	1,850	14,970,000	.....
Sweden	952	34,770,000	.....
Norway	762	9,585,000	.....
United States	620	13,450,000	.....
Russia (Europe)	462	23,039,000	.....
Bosnia-Herzegovina	405	2,632,500	.....
Bulgaria	230	.....	[b] $407,000
Servia	155	.....	[b] 148,000
Roumania	127	961,000	.....
Hungary	116	32,751,000	.....
Austria	91		.....
Japan	91	126,000	.....
Importing countries.			
Greece	85	.....	873,000
Switzerland	66	.....	3,653,000
German Empire	61	.....	48,750,000
France	61	.....	19,270,000
Italy	32	.....	5,964,000
Denmark	25	.....	4,817,000
Belgium	20	.....	16,330,000
Netherlands	10	.....	5,945,000
Great Britain	7	.....	93,950,000

[a] Average for five years, 1895–1899.
[b] Timber land largely in mountains and difficult of access. These countries will in time become exporters instead of importers.

DIVISION INTO EXPORTING AND IMPORTING COUNTRIES.

Since there are more statistics available for the countries of Europe than for others, they are first considered in detail in the order in which they occur in the following outline:

1. *Import countries.*—These may be subdivided into the four following groups, according to the reasons for their being import countries:

(*a*) Countries which, with a highly developed forest management and important forest possessions, themselves produce much wood, but in spite of this, on account of their important industries, can not do without foreign wood: German Empire, France, Switzerland, Belgium.

(*b*) Countries in which forest management plays but a small part on account of the small forest area: Great Britain, Netherlands, Denmark.

(*c*) Countries with only slightly developed forest management and little wood consumption: Italy, Spain, Portugal, Greece.

(*d*) Countries with relatively large forest areas, which, however, are in large part not yet fully developed, unequally distributed, or poorly managed: Servia, Turkey, Bulgaria.

2. *Export countries.*—These are Russia (with Finland), Sweden, Norway, Austria-Hungary (with Bosnia-Herzegovina), and Roumania.

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Import Countries.

EUROPE.

GERMAN EMPIRE.

Germany is unable to produce enough timber to satisfy its needs, and there is no doubt this condition will continue in the future.

Since 1863 the imports have exceeded exports, and the difference between them has been growing steadily, as shown in the two following tables.

It is worthy of note that since 1899 Austria-Hungary has taken Russia's place as the chief wood supplier of Germany. This is largely due to the greater development of the sawmill industry in Austria-Hungary, and to the fact that railroad communication is much better. Russia exports nearly all material by water.

If the average yearly import of the period 1880–84 is taken as a standard equal to 100, then imports have increased as follows:

Total timber imports and exports of Germany.[a]

Year average of—	Imports.		Exports.		Excess of imports.	
	Tons.[b]	Value.	Tons.	Value.	Tons.	Value.
1862–65	1,314,000	.....	1,181,000	.....	133,000	.....
1866–71	1,981,000	.....	879,000	.....	1,084,000	.....
1872–75	3,633,000	.....	1,153,000	.....	2,480,000	.....
1876–78	3,190,000	$43,875,000	1,183,000	$17,500,000	2,007,000	$26,375,000
1879–84	1,990,000	22,400,000	731,000	10,000,000	1,259,000	12,400,000
1885–87	2,253,000	22,400,000	501,000	6,425,000	1,752,000	15,975,000
1888–96	3,051,000	36,575,000	302,000	4,050,000	2,749,000	32,525,000
1897–1901	4,637,000	63,800,000	329,000	5,550,000	4,308,000	58,250,000
1902	3,932,000	46,400,000	342,000	5,575,000	3,590,000	40,825,000
1903	4,797,000	55,125,000	371,000	6,175,000	4,426,000	48,950,000
1904	5,049,000	59,475,000	323,000	5,825,000	4,726,000	53,650,000

[a] Endres: Forstpolitik.
[b] In this and the following tables 40 cubic feet is a fair equivalent for 1 ton.

Percentage of imports from most important countries which export to Germany.[a]

Year average of —	Russia.	Austria-Hungary.	Sweden.	United States.	Norway.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1880–84	46.6	37.0	7.3	0.7	2.4
1885–87	49.8	54.6	8.1	.8	2.1
1888–96	47.4	35.4	10.9	2.4	1.6
1897–1901	37.8	42.1	10.6	5.9	1.2
1902	35.3	43.0	12.5	7.4	1.2
1903	37.5	41.1	10.6	7.5	1.0

[a] Endres, loc. cit.

Increase of exports, taking the period of 1880–1884 as a standard of 100.[a]

Year average of —	Russia.	Austria-Hungary.	Sweden.	United States.	Norway.
1880–1884	100	100	100	100	100
1885–1887	129	113	134	156	109
1888–1896	166	156	244	514	111
1897–1901	201	a 283	358	1,950	127
1902	150	245	359	2,060	109
1903	206	285	371	2,571	111

[a] Endres, loc. cit.

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A glance at the above tables, with the knowledge that the forest resources of Germany are and have long been developed to their highest capacity, plainly indicates that Germany's imports will continue to rapidly increase. Her competition will be a large factor in bidding for any surplus timber in the future, and must not be lost sight of it in considering the possible sources of supply for the United States.

FRANCE.

A consideration of the following table shows that France will certainly continue to import, but the net imports are not appreciably increasing, since the population is about stationary, while the industries were already well established in 1875. The forest area is being extended, and coppice is being converted into high forest, so the imports will probably not increase to any extent for a number of years, but with growing industries they will certainly not decrease, and France will continue to be an important factor in competing for the surplus timber of the export countries.

Imports and exports of France.[a]

Year.	Imports.		Exports.		Excess of imports.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1875		$32,820,000		$8,280,000		$24,540,000
1880		55,600,000		6,960,000		48,640,000
1885		31,780,000		5,220,000		26,560,000
1890		31,580,000		8,580,000		23,000,000
1895		26,020,000		8,880,000		17,140,000
1900	1,658,000,000	35,400,000	1,123,000,000	9,920,000	535,000,000	25,480,000
1901	1,667,000,000	35,620,000	982,000,000	9,580,000	685,000,000	26,040,000
1902	1,584,000,000	33,820,000	935,000,000	9,320,000	649,000,000	24,500,000
1903	1,571,000,000	32,560,000	1,052,000,000	10,840,000	519,000,000	21,720,000
1904		33,480,000		10,780,000		22,700,000

[a] Endres, loc. cit.

France gets most of its sawn timber from Russia, Sweden, Norway, Austria, and America.

SWITZERLAND.

The following table shows that Switzerland, with its carefully managed and productive forests, is still increasing imports yearly with the development of industries, and must be reckoned with as a competitor in future bidding for timber.

Imports and exports of Switzerland.[a]

Year.	Imports.		Exports.		Excess of imports.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1878	180,000,000			$1,160,000		
1887	214,000,000					
1895	255,000,000	$2,580,000	54,000,000	380,000	201,000,000	$2,200,000
1900	273,000,000	3,160,000	64,000,000	520,000	209,000,000	2,640,000
1901	266,000,000	2,680,000	79,000,000	660,000	187,000,000	2,020,000
1902	278,000,000	2,840,000	77,000,000	640,000	201,000,000	2,200,000
1903	285,000,000	3,140,000	64,000,000	500,000	221,000,000	2,640,000

[a] Endres, loc. cit.

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The percentage of firewood constitutes over half of the total import, most of which comes from southern Germany and France. The import of sawed material exceeds that of logs, most of which is imported from Austria-Hungary.

BELGIUM.

The net imports of Belgium are surprisingly large when the small area of the country is considered, and they are increasing at a rapid rate. In the future they will certainly continue to increase, and help swell the demand of western Europe for wood from foreign countries.

Imports and exports of Belgium.[a]

Year.	Imports.	Exports.	Excess of imports.
1870	$4,480,000	$520,000	$3,960,000
1880	11,600,000	2,200,000	9,400,000
1890	14,080,000	2,660,000	11,420,000
1896	18,300,000		
1900	26,940,000	2,980,000	23,960,000
1901	26,520,000	2,800,000	23,720,000
1902	26,860,000	660,000	26,200,000
1903	[b] 27,980,000	580,000	27,400,000

[a] Endres, loc. cit. [b] Represents 68,835,000 cubic feet.

Sweden is the chief source of imports; then come Russia, Germany, and France.

GREAT BRITAIN.

Great Britain, on account of its scarcity of forests, its highly developed industries, and its great coal production, imports more wood than any other country in the world. The English wood consumption has an influence on the lumber trade of the whole world, and also on the price of lumber; therefore the inevitable increase in it is of great interest to the United States, especially in view of the amount of imports from Canada.

Imports of Great Britain.[a]

Year.	Quantity.	Value.
	Cubic feet.	
1880	321,159,400	
1890	360,236,500	$77,600,000
1900	496,247,400	125,484,050
1901	497,021,000	109,129,850
1902	498,516,400	122,156,950
1903	542,581,200	131,522,300
1904	458,900,000	

[a] Endres, loc. cit.

The greatest imports are in sawed and hewed wood. Scandinavia furnishes one-third of the imports, Russia one-fourth, and America one-fifth. The export is practically nothing.

DENMARK AND NETHERLANDS.

These countries have such small areas in forest as compared with their population that imports of timber are certain to increase, as they have steadily done in the last few years.

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ITALY.

The imports of Italy have slowly increased for some years, and the increase in population and development of industries will certainly more than offset any increased production of the forests, which are now mostly coppice and managed under a short rotation.

SPAIN, PORTUGAL, AND GREECE.

In spite of the fact that the industries of these countries are as yet scarcely developed, the forests can not supply the small consumption of wood. As mines and other industries are developed the imports must increase rapidly and help make the European deficit of timber much greater than at present, for the forest area per capita is extremely small.

TURKEY, BULGARIA, AND SERVIA.

These countries import timber in increasing amounts, although they are well wooded and industries are undeveloped. There is no question that their forest areas are sufficiently extensive to supply the home consumption were they under rational management and transportation facilities developed. But by the time these improvements are brought about, consumption will be much greater than at present, and the wasteful methods now in force will have greatly reduced the productive power of the forests. Considering the above facts, it seems safe to predict a continuation of the timber imports for some years at least.

EXPORT COUNTRIES.

EUROPE.

AUSTRIA-HUNGARY.

We come now to the exporting countries of Europe. Since the annual cut is greater than the annual growth, it is evident that the exports of Austria-Hungary must be reduced, for the forests are nearly all under careful management and their productivity can be increased only to a limited extent. As seen below the exports have steadily increased, and may continue to do so for some years, but not for long.

Wood export of Austria-Hungary.[a]

Year.	Exports.		Imports.		Excess of exports.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1880	1,746,000	$22,400,000	173,000	$1,150,000	1,573,000	$21,250,000
1885	2,258,000	31,600,000	223,000	1,750,000	2,035,000	29,850,000
1890	2,457,000	31,350,000	210,000	2,450,000	2,247,000	28,900,000
1895	2,398,000	32,850,000	156,000	1,850,000	2,242,000	31,000,000
1900	4,237,000	64,100,000	252,000	2,250,000	3,985,000	61,850,000
1901	3,903,000	55,650,000	268,000	2,200,000	3,635,000	53,450,000
1902	3,605,000	49,650,000	237,000	2,150,000	3,368,000	47,500,000
1903	4,238,000	58,700,000	267,000	2,300,000	.....	.....

[a] Endres, loc. cit.

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Wood export of Austria-Hungary—Continued.

Year.	Exported to—				
	Germany.	Italy.	Russia.	Balkan countries.	Switzerland.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1885	33	14	6	17	2.7
1890	43	11	7	11	2.7
1895	50	18	10	10	3.1
1900	62	14	6	6	2.4
1901	60	16	9	7	2.4
1902	51	18	11	8	3.0
1903	54	17	10	.....	2.9

RUSSIA.

The forests of Russia are capable of permanently producing much more timber than is now cut from them. In fact, the generally increasing deficit of wood in Europe must be met in large part from Russia. The following table shows how the exports of Russia have increased.

Russian exports to different countries.[a]

Year.	Tons.	Value.	Year.	Exported to—			
				England.	Germany.	Holland.	France.
				Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1885	.....	$13,230,000	1894	50	24	9	8
1890	.....	15,100,000	1895	46	28	8	8
1896	.....	23,360,000	1897	40	35	10	7
1900	.....	29,165,000	1900	41	32	12	7
1901	.....	28,625,000	1901	43	30	12	7
1902	3,460,000	27,700,000					
1903	4,090,000	32,650,000					

[a] Endres, loc. cit.

Russia's imports are limited to the southern parts, and are mainly from Austria and Roumania. In 1901 the total imports were 756,600 tons, with a value of $4,560,000.

FINLAND.

Finland can no doubt increase her exports considerably, for the private forests cut but 0.2 of a cubic foot per acre more than the annual growth, while the 38.7 per cent of the forests which the State controls do not cut nearly so much as the growth. The following table shows the rapid development of the sawmill industry in recent years.

Development of the sawmill industry, by years.[a]

	1870.	1886.	1890.	1892.	1895.	1896.	1899.
Number of sawmills	132	245	341	376	427	464	460

[a] Endres, loc. cit.

In 1899, 248 sawmills were run by steam and 212 by water. Sixteen thousand workmen were employed.

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Exports of Finland.[a]

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Cubic feet.			*Cubic feet.*	
1860		$1,920,000	1885	79,425,000	$7,880,000
1865		3,740,000	1895	122,491,000	12,200,000
1870		2,640,000	1901	164,851,000	20,300,000
1875		7,540,000	1902	168,381,000	21,620,000
1880		11,140,000	1903	211,800,000	26,200,000

[a] Endres, loc. cit.

SWEDEN.

Sweden's annual cut is less than the annual growth, and the forests may be expected to supply the home demands and allow the country to continue to increase exports to some extent. The following table shows the rate of increase in them of late years.

Exports of Sweden.[a]

Year average of—	Quantity.	Value.	Year average of—	Quantity.	Value.
	Cubic feet.			*Cubic feet.*	
1871–1875	116,490,000	$21,175,000	1897	246,750,000	$27,600,000
1876–1880	130,960,000	22,075,000	1898	236,160,000	36,600,000
1881–1885	161,670,000	24,125,000	1899	239,690,000	35,150,000
1886–1890	183,560,000	24,625,000	1900	245,690,000	38,450,000
1891–1895	210,040,000	28,275,000	1901	219,920,000	32,975,000
1896	235,800,000	32,975,000	1903	243,570,000	

[a] Endres, loc. cit.

Great Britain takes about half of the Swedish exports, then come France, Denmark, Germany, Netherlands, Cape Colony, Australia, and South America. Planed boards go chiefly to Netherlands, Cape Colony, England, and Australia.

The large number of floatable streams in Sweden have been important factors in enabling it to take one of the foremost places in the world's timber market. The wood industry has been intensively developed. In 1898 there were 1,030 saw and planing mills, which employed 40,700 workmen; in addition there were 501 other wood-working establishments, with 22,300 workmen. As motor power, 507 turbines, 706 steam engines, and 178 electric motors were used.

NORWAY.

The forests of Norway are now being overcut, so that the exports, which have not increased much since 1870, will evidently decrease in the future.

Exports of Norway, by amounts and values.[a]

Year.	Quantity.	Value.
	Cubic feet.	
1870	67,211,000	
1876–1880	64,964,000	
1886–1890	65,517,000	$7,875,000
1895	59,128,000	6,900,000
1900	70,671,000	10,671,000
1901	63,717,000	8,900,000
1902	69,259,000	9,575,000
1903	75,260,000	11,125,000
1904	63,434,000	9,075,000

[a] Endres, loc. cit.

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Exports of wood-pulp material are also very important, and in 1904 reached a value of $7,500,000.

The exports were distributed as follows:

Distribution of timber exports of Norway.[a]

Year.	South Africa.	Great Britain.	Belgium.	Netherlands.	France	Germany.	Denmark.	Australia.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1881	.....	64.0	2.8	10.0	10.0	4.5	4.3	.....
1887	2.0	63.4	7.2	6.6	8.6	4.3	2.1	3.3
1898	2.5	57.0	9.0	9.0	5.0	5.0	.....	7.0
1900	2.1	63.0	8.4	6.1	4.9	4.5	1.9	5.9
901	3.0	63.0	7.4	4.9	5.5	3.9	1.7	6.6

[a] Endres, loc. cit.

A little goes to Sweden, Iceland, Spain, and Brazil.

ROUMANIA.

Satisfactory data as to the cut and growth of forests in Roumania can not be had, but the forest area per capita is too small to expect much increase in export in the future, although of late years it has grown rapidly, as transportation developed.

SUMMARY FOR EUROPE.

The following table shows the great increase in the export timber trade of the world's leading export countries.

Value of export timber trade of leading export countries.[a]

Country.	Average of years—					
	1881–1890.	1891–1895.	1896–1900.	1901.	1902.	1903.
Sweden	$27,100,000	$31,450,000	$40,675,000	$37,250,000	$38,750,000	$41,500,000
Norway	9,350,000	7,850,000	11,325,000	10,000,000	10,750,000	14,000,000
Finland	8,700,000	10,175,000	17,500,000	20,300,000	21,625,000	26,250,000
Russia	16,925,000	22,700,000	29,250,000	30,900,000	29,925,000	35,250,000
Austria-Hungary	23,875,000	25,800,000	42,500,000	47,300,000	42,200,000	49,900,000
United States	21,375,000	21,250,000	40,300,000	41,375,000	52,075,000	51,550,000
Canada	23,000,000	23,450,000	27,850,000	29,850,000	33,500,000	31,400,000
Total	130,325,000	142,675,000	209,375,000	216,975,000	228,825,000	249,850,000

[a] Endres, loc. cit.

In 1903 the total import of Europe was 1,164,900,000 cubic feet,[a] and the total export 1,023,700,000 cubic feet, showing an excess import of 141,200,000 cubic feet.

This balance is made up chiefly from Canada and the United States. A brief summary of Europe leads to the following conclusions:

1. The leading import countries, Great Britain, Germany, France, Belgium, Switzerland, etc., are rapidly increasing the amount of their imports, and this increase is certain to continue.

[a] Endres, loc. cit.

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2. Russia, Finland, and Sweden only of the export countries can increase to any great extent their export without reducing their timber capital.

3. Norway and Austria-Hungary are already overcutting, and will in all probability have to reduce their exports in the future.

In view of these facts, with the rising prices of timber, it is certain that any increased exports from Russia, Finland, and Sweden will be eagerly competed for by Great Britain, France, Germany, etc., and there will be no surplus of any consequence for the United States, handicapped as it is by greater distance, and hence greater cost for transportation. Hence in case of a failure of our timber resources, we must look to other than the European countries for a source of supply.

AFRICA.

EGYPT.

Egypt has no forests in the true sense of the word, but is interesting as a buyer. The industrial development and railroad building which the last few years have seen in Egypt, and which give every sign of continuing, will certainly result in increased demand for timber. The following table shows the important increase in it of late years.

Import of Egypt.

Year average.	Structural timber.	Firewood.	
		Quantity.	Value.
		Cubic feet.	
1885–1889	$1,547,000		
1890–1894	2,161,500	3,187,000	$220,000
1895	2,481,500		
1896	2,122,000		
1897	2,505,500	2,355,000	136,000
1898	3,170,500		
1899	3,213,500		

From A. A. Radzig, Forests and Forestry in Various Countries, A Statistical Investigation.

SOUTH AFRICA.

The forests of South Africa are entirely inadequate to supply home needs, and the imports are certain to continue to increase with the population and industrial development.

Imports of Cape Colony and Natal.[a]

Year.	Cape Colony.	Natal.
1890–1895	$575,500	$417,000
1895–1899	859,000	876 000

From A. A. Radzig, loc. cit.

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These imports amount to 5,000,000 cubic feet, the annual average for the years 1895–1899. The following countries sent in 1895 to South Africa the amounts shown below:

Exports to South Africa.

Country.	Quantity.	Country.	Quantity.
	Cubic feet.		*Cubic feet.*
Sweden	2,465,777	India and Burma	56,679
Norway	1,041,327	New Zealand	32,548
United States	1,020,144	South Africa	1,592
Great Britain	185,121		

From B. P. Mrozovski, Brief Review of Lumber Industry.

CENTRAL AFRICA.

The forests of Central Africa are little known, but their area is not so great as commonly supposed, and the chief species of commercial value are expensive hard woods, which have no bearing on the question of the supply of common timber for the United States.

NORTH AFRICA.

The countries of North Africa, other than Egypt, have barely sufficient forest for the low home consumption, except Algeria, which has already had to import timber. With increased railroad building and general development this import will increase.

Imports of Algiers.

Year average.	Value.
1890–1894	$813,500
1895–1899	814,000

From B. P. Mrozovski, Lumber Industry.

A review of Africa shows, then, a timber import destined to increase in the future in all but the central part, which is utterly undeveloped and can export only costly woods.

ASIA (EXCLUSIVE OF SIBERIA).

CHINA.

The reasons why China will continue to import in rapidly increasing amounts have been fully brought out; that it will take the surplus of eastern Siberia and continue to draw on the United States and Canada is certain.

Imports of structural timber of China.

Year average.	Value.	Year average.	Value.
1867–1870	$261,500	1885–1889	$744,000
1871–1875	440,500	1890–1894	1,074,500
1876–1879	616,500	1895–1899	1,201,000
1880–1884	592,000		

From B. P. Mrozovski, Lumber Industry.

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PERSIA.

The forests of Persia are limited in extent and do not produce woods of common use to an extent to supply any timber for export.

CEYLON, STRAITS SETTLEMENTS, INDO-CHINA, ETC.

These minor countries of Asia are too little known and their forests are too little explored to give any basis for definite predictions. However, it may be said in a general way that they will not develop sufficiently for many years to import much structural timber and their exports are solely of valuable woods which are not important in this discussion.

BRITISH INDIA.

The exports of India consist of teak and other valuable woods, and it is found necessary to import structural timber. Thus India, while an export country from the point of view of value, is an import country if only common woods be considered, and will no doubt so continue, for any greater supply made available by better transportation facilities will be offset by greater consumption, following development of industries. The following table gives the exports of India for 1903–4, and shows the kind of forest products exported.

Exports of India, 1903–4.[a]

Material.	Quantity.	Value.
	Tons.	
Caoutchouc	90	$115,732
Lac	11,781	9,079,320
Sandal, ebony, and other ornamental woods	.....	403,163
Cutch and gambier	5,652	657,904
Myrobolans	61,480	1,403,429
Teak timber	73,913	3,048,536
Cardamoms	128	112,538
Total	.....	4,820,622

[a] Schlich, Forest Policy.

JAPAN.

Conflicting figures are given by different statisticians on the timber trade of Japan, according to how much they include under timber. If only structural timber is considered, Japan is an importing country by a small margin, while if all woods be considered it is an exporting country. Japan can supply home needs when all the forests are accessible, but will probably not be able to export any saw-log timber. Certainly this country can not look for any supplies from Japan, for any surplus will in all probability go to Manchuria, since the shorter distance and Japan's interest in developing that country would enable it to outbid the United States. The following table gives the exports and imports of wood and wood products, except match wood, in recent years.

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Value of exports and imports of Japan.

	1892.	1896.	1900.	1901.	1902.	1903.	1904.
Export	$135,000	$460,000	$980,000	$655,000	$660,000	$980,000	$1,335,000
Import	40,000	145,000	450,000	355,000	380,000	335,000	255,000
Net exports	95,000	315,000	530,000	300,000	280,000	645,000	1,080,000

[a] Endres, loc. cit.

SUMMARY FOR ASIA.

A brief summary of Asia results in the following conclusions: (1) China and Australasia are import countries; the imports of the former will increase rapidly, while Australasia will probably not increase the amount of her import much; (2) Japan and India export valuable woods and import structural timber; (3) these countries will be buyers of saw-log timber, and can not be counted on as possible sources of supply for the United States, but must be regarded rather as possible competitors; (4) the Philippines, though now an importing country, should be able to export sufficient timber, when the wood industry is developed, to offset the imports.

AUSTRALASIA.

There is a difference of opinion as to whether poor condition resulting from abuse or inaccessibility is the cause of the insufficiency of Australasia's forests to supply home needs at present. In any case, the imports are sure to continue to increase for some years, and it is very unlikely that any surplus timber for export will ever be produced. The following table gives the net exports or imports of each of the colonies for the period 1894–1899:

Value of net exports and imports by colonies.

	Net exports.		Net imports.
Western Australia	$789,500	Victoria	$1,364,000
New Zealand	758,500	New South Wales	1,344,000
Tasmania	154,500	South Australia	1,003,500
Queensland	29,000		
		Total	3,711,500
Total	1,731,500	Total net exports	1,731,500
Net imports of all Australasia			1,980,000

From A. A. Radzig, loc. cit.

HAWAII.

Hawaii, with only about 1,175,000 acres of forest, and developing industries, can export only a trifling amount of timber.

THE PHILIPPINES.

The Philippine Islands contain about 49,000,000 acres of wooded land, and the estimate per acre given is 2,500 board feet, which gives a total of 122,500,000,000 board feet of merchantable timber. The Philippines import timber for two reasons—the inaccessibility of

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their own forests at present, and the need of light, easily worked wood. In time, as transportation is developed and the forests are made accessible, the native forests should supply nearly all the home consumption, and leave enough over for export to equal or surpass the quantity imported of certain classes of timber which are not found in the islands. But owing to the small amount of total stand, and the fact that there are only about 2 acres per capita in commercial forest, the increase in consumption with development of industries and increase in population will prevent the timber export from ever being an important factor in supplying the United States.

TROPICAL AND SOUTH AMERICA.

MEXICO, WEST INDIES, AND CENTRAL AMERICA.

These States now import timber not so much because they have none, but for the reason that it is at present inaccessible. Whether forest exploitation will develop as rapidly as other industries and the amount of imports remain stationary or be reduced or whether they will increase can not be safely predicted. It would seem that there will always be an export of mahogany, cedar, and other valuable woods, and it is most probable that there will continue to be an import of common woods.

SOUTH AMERICA.

For many years South America will continue to export hard woods, dyewoods, etc., and import lumber and construction material. Eventually, as the countries develop, the great forests now inaccessible will be opened up, and should supply home consumption, which will have increased greatly by that time. The imports will no doubt not increase to any serious extent, but are more likely to diminish. At the same time, the exports can not be counted on as a source of supply for this country for the reason above stated—that by the time the forests are accessible the country will have developed so much that home consumption will have greatly increased, and also because the forests are so situated that logging and transportation will be so costly as to prohibit the use of the wood for construction in this country.

NORTH AMERICA.

ALASKA.

Alaska has approximately 107,000,000 acres of forest land, of which 37,000,000 acres, situated along the south coast and the river valleys, bear relatively heavy forests of valuable species, while the remaining 70,000,000 occupy the interior to the limit of tree growth. The interior forest consists for the most part of scattered stands, and only from 50 to 75 per cent of it can be said to be actually forested. Estimating these stands to run 500 board feet to the acre, the interior forest contains not over 21,000,000,000 feet, board measure. This timber runs small and knotty, and is insufficient to supply the needs of the mining population, largely because much of it is inaccessible with the present means of transportation. With the increasing development of mines it is safe to assume that this interior forest will

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continue to be needed for local consumption and may fall short of supplying it. The forests of the south coast and of the river valleys, on the other hand, are often dense and the trees large. Toward the north the trees fall off in size and the forest gradually assumes the character of the northern forest. Estimating the average stand per acre at 2,000 feet, the total stand for this forest amounts to 75,000,000,000 feet, board measure, not quite twice the annual lumber cut of the United States. In this part of Alaska fisheries and oil developing are the principal industries, so that the home consumption of timber is not so great, and in all probability this region may in the future, when transportation is developed, be able to export timber to the United States. However, owing to the relatively small amount of forest, it can contribute but a very small part of the timber used by this country.

CANADA.

The Canadian forests are being cut and burned faster than they are growing, as shown in the first part of this article, and yet the exports are growing steadily, as shown below:

Yearly average and values of exports of Canada.[a]

1881–1890	$23,000,000
1891–1895	23,450,000
1896–1900	27,825,000
1901	29,850,000
1902	33,500,000
1903	31,400,000

In 1904 the value of wood imported was $9,000,000.

It is evident, then, that Canada, the only country which the United States can now count on for any considerable amount of timber, will not long remain a source of supply to the United States.

CONCLUSION.

The review of the timber trade of the various countries of the world shows a steady increase in wood consumption and imports of nearly all the leading import countries, and but three important countries, Russia, Finland, and Sweden, which can increase their export without lessening their forest capital. This increase will be needed in western Europe to make up the growing deficit there, and will not be a source of supply for the United States. Thus the tendency is toward a greater overcutting of timber on the part of the export countries, to make up the increasing deficit of the import countries, which policy, if continued, would lead to a universal shortage, with no surplus to draw upon. This picture, gloomy as it may seem, is offset by the birth of a new economic force—the general appreciation of the value of forests and the movement toward the introduction of rational forest management by all civilized peoples. There is no doubt whatever that there is enough accessible actual and potential forest land in civilized countries to produce, under proper management, an abundance of timber to supply indefinitely the world's growing demand.

Doctor Schlich states, in his Forest Policy, that by planting up waste lands in Great Britain, much of the annual import could be

[a] Endres, loc. cit.

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replaced by home-grown timber. If any material results can be expected in Great Britain, this country, with its great existing forests and large amount of permanent forest land, can certainly supply its timber needs. Not only of necessity, in view of the lack of any adequate foreign source of supply, but also from national pride and the desire to preserve a tremendous native industry, the United States should introduce rational forest management. At present, forest management would consist in large part of conservative treatment of existing forests with a relatively small amount of planting. If postponed until a timber shortage forces the United States to action, we should face the problem of the slow conversion of scrubby woodland into productive forest and the costly planting of denuded wastes on a very large scale. While the present area of wooded land in the United States is usually estimated as 545,000,000 acres, some of this is of no commercial value, and much is inevitably destined, with the increase in the population of the country, to be cleared for agriculture. The area of land so situated as to be permanent forest land is about 450,000,000 acres, of which 100,000,000 will consist of farm wood lots. The inevitable increase in wood consumption, following increase in population and growth of industries, will thus have to be supplied from a diminished forest area. Therefore the only solution of the problem of a wood supply is to begin now to prepare ourselves for making a diminished forest area supply an increased population. This means that the land should be surveyed and classified by the Government, and forest management applied to the permanent forest land now—before it is too late.

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COST OF FORESTRY IN DIFFERENT COUNTRIES.

By H. S. Graves,
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A comparison of the expenses of forestry in different countries is necessarily unsatisfactory, because the forests differ in character and there is a very wide difference in economic conditions. In Europe systematic forest management was introduced many years ago. The forests are thoroughly organized, and the expenses of administration represent their maintenance, protection, and operation. In this country the work of forest organization has only just been started. Even our National Forests have only been roughly explored, and we have only estimates of the standing timber growing in them and its value. There are almost no roads, only a few satisfactory maps, insufficient demarcation of boundaries, very few fire lines, and the work of construction of headquarters, ranger cabins, telephone lines, etc., remains as yet to be carried out. Almost no working plans have been made for our National Forests, and the life history of the trees must be more completely studied before satisfactory methods of silviculture can be devised. Practically all of the work of organization of the forests remains to be done.

Other conditions enter in also to affect a comparison of expenses. In America and India there is great danger from fire, and large sums of money must be spent on providing adequate fire protection. In Europe, on the other hand, the danger from fire is very small in most places, largely because of a dense population, an enlightened public sentiment, and an organization of the forests which is the result of many years' work.

Again, the market conditions affect the kind of forestry which can be practiced. With constant good markets, as in Europe, it pays to use more intensive methods of forestry than where only certain classes of timber can be sold. For this reason the Germans can afford to spend on cultural operations proportionally larger sums than the Americans. In the same way the total expenses of forestry in a country are influenced by the methods of timber sales. If timber is sold on the stump the outlay is less than if the government does its own logging. The last system involves a large annual expense for logging which does not appear in the budget of a country which sells its timber standing.

These facts must be borne in mind in the study of the forest budgets of Germany, France, India, and the United States, which are discussed in the following pages.

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A comparison of expenses in these different countries shows some astonishing differences. Prussia, with its forest of a little over 7,000,000 acres, spends each year about $14,000,000; India, with about 65,000,000 acres (including only reserved and protected forests), spends only about $4,000,000. The United States, with about 168,000,000 acres of national forests, spends only about $3,400,000. If these data are expressed in terms of the amount per acre, it is seen that the expenditure by Prussia is over $1.90 per acre as against that of the United States of about 2 cents per acre. In this connection it must be borne in mind, however, that Prussia did not expend so large a sum on forestry at the beginning of its work of organization. With the development of forestry and the increased demand for timber and the resulting high prices, it has been profitable to use more and more intensive methods and invest greater sums each year in forest cultivation. This is well illustrated in Prussia, which in 1849 spent for regularly recurring expenses about $2,000,000 each year, compared with $12,500,000 at the present time.

In other words, the expense of administration increases with the development of forestry. This is possible only when there are increased returns as a result of the increased initial expenses. This principle is illustrated in Prussia, where the net income has increased from less than $7,000,000 in 1848 to about $14,000,000 at the present time.

To carry out further the comparison of expenditures in the different countries, Prussia spends for salaries, including both administrative and executive forces, 52 cents per acre; France, 38 cents; India, a little over 2 cents; and the United States, a trifle over 1 cent. The average area in charge of a supervising forester in Prussia is about 10,000 acres; in the United States it is over 1,000,000 acres. While our western forests will not require a division into so large a number of administrative units as those of Prussia, the contrast is nevertheless exceedingly instructive.

Although the Prussian forests are already thoroughly organized, nevertheless the work of constructing and extending roads and bridges, dams, etc., is being pushed each year with an expense of over $500,000, and that is about the sum which is now being expended on all kinds of construction work in our national forests. In other words, for construction work, including buildings, telephone lines, etc., Prussia spends about 16 cents per acre and the United States about 3.5 mills. In reality the comparison ought to be reversed, for construction work constitutes an exceedingly important part of the first organization of a forest.

The great yield of timber and large returns in money from the European forests are the result of careful, intelligent forestry. Not only are the forests protected, but they are constantly improved; they are properly thinned to obtain the best possible conditions of growth, and open areas are planted with trees when reproduction can not be secured naturally. All of this involves expenditure of money. Such improvement work costs in Prussia $1,700,000 each year, or 23 cents per acre. Even in India there is an expenditure of over $173,000 a year for cultural operations. The expenditure in the United States is only about $50,000 for this item, a sum so small that it can hardly be expressed in terms of expense per acre.

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One of the great problems in the United States is the training of men to handle the work of the national forests. At the present time the number of trained men available for the administration of the forests is entirely inadequate. The country is fortunate in having private schools which are educating men for federal service. The United States Forest Service is aiding these schools to a small extent, but the total amount expended is probably not over $1,000. This may be compared with $50,000 spent in Prussia, $37,000 in France, and $26,000 in India.

It is obvious from this brief comparison of expenses in different countries that the amount of money spent on the administration of the National Forests in this country is exceeding small, and it is perfectly obvious to anyone who knows the conditions that a very much larger amount is required to accomplish the purpose of the people of the United States in managing their government forests.

Expenditures for forestry in Prussia, France, India, and the United States.

PRUSSIA.

[From the budget of 1908.]

	Amount.	Per acre.
Recurring expenses:		
Superior staff	$1,433,590.00	$0.19
Subordinate staff	2,468,911.00	.33
Rents and expenses of offices	870,085.00	.12
Scientific work and education	96,750.00	.013
Extraction of forest products	3,082,750.00	.42
Cultural work	1,710,500.00	.23
Construction and maintenance of buildings	598,750.00	.08
Construction of roads, dams, etc	571,500.00	.08
Land purchase	262,500.00	.04
Administration of communal forests	492,000.00	.07
Other expenses	683,914.00	.09
Total	12,521,250.00	.....
Extraordinary expenses	1,149,450.00	.16
Grand total	13,670,700.00	.....
Average	.....	1.823

FRANCE.

[From the budget of 1907.]

Recurring expenses:		
Superior service	$500,000.00	$0.17
Subordinate	614,000.00	.21
Service and expenses	145,400.00	.05
Education	37,200.00	.01
Cultural and protection	243,900.00	.08
Construction work	675,200.00	.23
Exploitation	83,000.00	.02
Hunt	15,200.00	.005
Special taxes	420,000.00	.15
Miscellaneous	52,400.00	.02
Total	2,876,300.00	.....
Average	.....	.945

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Expenditures for forestry in Prussia, France, India, and the United States—Con.

INDIA.

[Expenses for 1905-6.]

	Amount.	Per acre.
Recurring expenses:		
Superior staff	$774,884.00	$0.012
Exchange compensation allowance	28,083.00	.0004
Subordinate staff (including rangers, foresters, and guards)	704,218.00	.011
Office establishments (including contingencies)	347,171.00	.005
Extraction	1,478,176.00	.027
Roads and buildings	287,668.00	.004
Fire protection	192,596.00	.003
Cultural operations	172,763.00	.003
Live stock, stores, and plant	169,384.00	.002
Working plans	28,914.00	.0004
Rent for leased forests	285,979.00	.004
Miscellaneous	69,660.00	.001
Expenditure on realization of revenue from forests not managed by Government	7,121.00	.....
Forest science and education (including all "A" and "B" charges of forest school)	26,656.00	.0004
Extraordinary expense	179,664.00	.003
Grand total	4,138,691.00	.0762
Average	.....	.....

UNITED STATES.

[Expenses for 1907-8.]

Administration (for the general administration of the Forest Service)	$162,703.38	.....
Use (for the use, maintenance, and protection of the National Forests)	2,363,394.64	.....
Improvements (for the construction and repair of permanent improvements upon the National Forests)	592,169.19	.....
Studies (for studies necessary for the use and protection of the National Forests and of other forests in the United States, and to promote economy in the use of forest products and the distribution of their results)	297,840.40	.....
Total	3,416,107.61	.....

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EXTENT TO WHICH FOREIGN METHODS OF FOREST ADMINISTRATION ARE SUITED TO CONDITIONS IN THE UNITED STATES.

By S. T. DANA,
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INTRODUCTION.

In the United States the science of forestry is still in the formative stage. Knowledge of the characteristics and requirements of the many species of trees composing the forests is limited; the total amount and distribution of forest wealth is not accurately known; and methods of administration are not as yet settled, but are subject to frequent change. In Europe, on the contrary, forestry as practiced to-day is the result of centuries of gradual evolution, and is consequently thoroughly systematized and its methods firmly established. While conditions in the United States differ materially in many respects from those in foreign countries, many of the general principles of forest administration are nevertheless of universal application, and the long experience of those countries in developing systems satisfactory to them may be of much value in establishing methods suited to conditions in the United States.

GERMANY.

Germany is generally acknowledged to have attained the greatest development in the practice of forestry, and is held up as a model of what may be accomplished by scientific management of the forests. There is scarcely a policy or a practice that has not been tried in that country, so that a knowledge of what has been found to yield the best results, and has been adopted as the permanent policy of the Empire, is of particular interest.

As in all other countries during the early stages of their development, the forests were at first neglected and abused. Not until the fear of a timber famine began to be felt was any effort made to protect or perpetuate them. As early as the fourteenth century, however, the supply of wood in certain localities had become so depleted that alarm for the future prompted the first attempts at forest protection. The earliest record of commercial planting is for 1368, when the city of Nuremberg successfully sowed several hundred acres to pine, spruce, and fir. These early attempts at forestry were local, however, and it was not until after 1500 that there was any systematic and general development of forest methods.

Following the close of the Middle Ages came a period of industrial development which, together with further settlement of the country, hastened the progress of forest destruction. With the danger of a

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general scarcity of timber confronting them the people were forced to devise some means of preventing waste and of securing a second crop. A beginning was accordingly made in all of the various branches of forestry, but it was not until within the last fifty to one hundred years that a settled policy of management became fully established.

It is interesting to note that in Germany the development of forestry was originally due almost entirely to fear of a timber famine and to the recognized necessity of taking immediate steps to maintain the wood supply. The necessity of preserving forests about the headwaters of streams in order to prevent and control floods and erosion was not one of the first causes leading to the forestry agitation, but this necessity is now clearly recognized, and protection forests are maintained at high altitudes throughout the mountainous districts, in which cutting is either wholly forbidden or is carefully restricted. This early neglect of the protective value of a forest cover was due largely to the fact that the greater part of Germany (75 per cent) is either level or hilly in character, and that the remaining mountainous portion was not heavily cut at first.

In Germany the fundamental principle of forestry, that the annual cut should equal the annual growth, has been clearly recognized. Accordingly, no attempt has been made to withhold the forest from use, but rather to regulate its use and to increase the amount available for cutting by increasing the annual growth through various cultural methods. This policy has been remarkably successful, as is evidenced by the fact that the annual growth for the Empire as a whole reaches the high average of 48.7 cubic feet per acre. This is in striking contrast to the United States, where the annual growth is estimated at about 12 cubic feet per acre. The excellent results obtained in Germany are due to the very intensive systems of management in use. These are made possible by the economic and industrial condition of the country. While 25.9 per cent of the total land area is covered with forest, this is well distributed and is everywhere broken by patches of cultivated land and by settlements. The forest area per inhabitant is only 0.61 acre as against more than 6 acres per inhabitant in the United States. The entire forest is therefore more or less readily accessible and open to utilization. Good roads exist throughout the forest and greatly facilitate transportation.

In money returns the German forests are still more strikingly in advance of the United States than in wood returns. In the state forests of Prussia in 1902 the gross receipts amounted to $3.20 and the net receipts to $1.66 per acre. Yet Prussia, although the largest, shows smaller returns than any other of the important States in the Empire. Wurttemberg, for example, in 1901 received from its state forests gross receipts amounting to $8.25 and net receipts amounting to $5.41 per acre. This is in contrast to the gross returns of $0.011 and the net returns of $0.005 per acre received from the National Forests in the United States in 1907–8. These much larger returns are made possible not only by the more intensive systems of management in Germany, but also by the excellent market conditions and high prices for wood. The demand for all forest products is so strong and so uniform that stump and fagot wood and even leaf litter can, in nearly all cases, be readily marketed. Waste is accordingly so far reduced that practically the whole tree is utilized, as against only 50

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per cent or less in the United States. Wood prices are uniformly from three to five times higher in Germany, and there is often a still greater discrepancy between stumpage prices in the two countries. This, of course, greatly increases returns, and it is a well-known fact that where the highest prices prevail the practice of forestry has also reached its highest development.

The returns per acre from the forest bear a fairly uniform ratio to the amount spent on it, which is very interesting and worthy of note. Greater expenditures are in nearly every case followed by greater returns. Prussia, for example, spends less on its forests than any other of the larger German States and also receives smaller returns. In 1880 it spent $1.09 per acre on its state forests and received a net return of $0.92; in 1902 an expenditure of $1.54 brought a net return of $1.66. Baden in 1880 spent $2.17 and received a net return of $2.38 per acre; while in 1902 it spent $3.89 and received a net return of $5.08. In general the net returns per acre pretty closely approximate the expenditures, so that any increase in the amount expended on the forest means a corresponding increase in the receipts.

In developing the different systems of forest management, the Germans have been particularly favored in that the forest is comparatively simple in composition, with only a few species of great importance. This simplicity in composition, which has been still further increased by the methods of management employed, is in marked contrast to conditions in the United States, where there are a great many species of commercial value, and a very irregular and complex forest. This difference in the character of the forests makes the German methods of management, as a rule, inapplicable in the United States without modification. The general principles involved are, however, frequently of universal application and have already been successfully used in the United States; and the German experience is also of value in pointing out errors to be avoided.

The Germans have found conifers to be a more valuable crop and to produce a larger yield than hard woods. They were fortunate in having the conifers largely predominant in the original forest, and the tendency has been to increase their representation, until now the conifers form 65½ per cent of the total forest area and the hard woods only 34½ per cent. Forests grown from seed have also been found to be more profitable than sprout forests, and have consequently been encouraged. In the management of the forests in the United States these facts have not been generally recognized; coniferous forests have been cut over and abandoned to an inferior growth of hard woods, while hard wood stands have been allowed to exhaust themselves by repeated sprouting, with no attempt to secure seedling reproduction.

The intensive forestry practiced in Germany to-day is, of course, the result of a gradual development through many years of experiment, accompanied by frequent changes in methods and opinions. For a long time the methods used were entirely of empiric origin, and as always happens in such cases the development of satisfactory methods was consequently slow. In 1870, however, the need of thorough and systematic experiments as a basis for technical work was officially recognized, and a forest experiment station was established in Baden in connection with the Polytechnikum at Karlsruhe. Other States followed this example, and the policy has met with much

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favor and has been largely instrumental in the development of a more satisfactory forest practice than was possible before. This increased efficiency in technical work, as a result of the establishment of forest experiment stations, is of particular interest to the United States, where this method of carrying on investigative work has just been adopted.

In regard to the part taken by the State in forest management in Germany two facts of particular interest stand out prominently: (1) The State exercises at least a controlling interest in the majority of the forests, and (2) the forests under state ownership uniformly yield considerably larger returns than those under private or communal ownership.

In Germany the Empire, or central Government, takes no part whatever in the management of forests, which is left entirely to the individual States composing the Empire. These, however, do not correspond at all closely to the States of the United States of America, but are rather independent countries which are simply banded together for political purposes. State ownership in these States, therefore, corresponds quite closely to federal ownership in the United States. In Germany, as a whole, 31.9 per cent of the forests are under state ownership, while in the United States 26.1 per cent are under national and state ownership. In Germany, however, the State takes an important part in the management of both communal and private forests, and 66 per cent of the total forest area is actually under state control. The United States has no control over the 74 per cent under private ownership, so that there is a most decided contrast between the influence exercised by the Government in the management of the forests in the two countries.

The advantages of state ownership are clearly evident in the greater returns yielded under it. For Germany, as a whole, the state forests yield 58.5 cubic feet per acre, while the private forests yield only 39.8 cubic feet; communal forests are intermediate, with an annual yield of 53.1 cubic feet. This high yield is undoubtedly due to the strong influence which the state exercises in the management of the communal forests, all of which are subject in some degree to state supervision. This varies from merely restricting the clearing or selling of the forests to complete management of them by the state precisely as if they were state property. The stricter the supervision of the state the greater are the returns in almost every case.

Communal forests are a natural result of the development of property conditions in Germany and are a European institution which has no counterpart in this country. They are an important source of revenue to the community, sufficient in some cases not only to make taxation unnecessary, but even to yield a surplus to be divided among the citizens. Although circumstances have not led to the establishment of communal forests in the United States, there is apparently no good reason why they should not be established with equally satisfactory results.

In addition to exercising more or less control over the communal forests, the State retains the right to regulate the cutting of certain classes of private forests without regard to the wishes of the owners. For example, private forests can not be cut clear where they are considered necessary for the protection of watersheds or the prevention of torrents. This is in marked contrast to the treatment in the United

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States, where the national and state governments have not in any way attempted to restrict private owners in the management of their forests. The recent decision of the supreme court of Maine, however, that the legislature has a constitutional right to pass laws regulating the cutting of timber on private land where the cutting is liable to be detrimental to the public welfare indicates that the very desirable oversight by the State of private management in cases of this sort may in time be secured also in the United States.

On one point the authority of the state in Germany is limited even in the management of its own forests. This is in the so-called "servitudes," or "rights of user," which custom has brought into existence and which give certain individuals the right to appropriate to their own use certain products of the forest, such as the fagot wood or litter. These in time became such a hindrance that in Bavaria in 1852 the establishment of new servitudes was positively forbidden. Other States had the same experience, and attempts were made to get rid of these servitudes, with such success that they have mostly been abolished or restricted so far as to be no longer impediments in forest management. The United States is fortunate in never having been burdened by such rights, and the experience of Germany is a warning against allowing them to develop.

In practically all of the German States the forest administration comes under either the department of agriculture or that of finance. The administrative machinery is more or less alike in all of the States, and Prussia, which is the largest, may be cited as representative. There the technical work of the forest service is divided into three distinct parts, under directing, inspecting, and executive officers. The work of direction lies with the central office, at the head of which is a technical man known as the "oberlandforstmeister," assisted by council of technical deputies, or "landforstmeister." This central office has entire charge of the forest policy of the administration, questions of personnel, approval of working plans, and direction of forest schools, and in all things pertaining to the forest service acts as a court of last resort. For purposes of practical administration the country is divided into several inspection districts, each under an "oberforstmeister," assisted by a number of "forstmeister." The power of these inspectors is not merely advisory, but they are virtually administrative officers in practical control of their particular districts. These districts are, however, still further subdivided into smaller districts, or working units, each under an executive officer known as an "oberforster," who is in charge of a number of "forster," on whom falls the actual administrative and executive work in the woods.

It is evident that this system is quite similar to the present organization of the Forest Service in the United States, where there is a central directing office with six separate administrative districts, all of which report to the central office. These districts are further subdivided into National Forests, which form the administrative units. The forest supervisor, therefore, corresponds to the German oberforster and the forest ranger to the forster.

While there is thus seen to be a striking similarity between the general systems of organization in the two countries, there is an equally striking difference between the sizes of the administrative units. In the United States the average size of a district under a supervisor is

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over 1,000,000 acres; in Prussia the average area under an oberforster is about 10,000 acres, and in the little Duchy of Saxe-Coburg it is only 2,000 acres. In the United States the average size of a district under a single ranger is over 100,000 acres; in Prussia the average size of the area under a forster is about 1,700 acres, while in the Grand Duchy of Baden it is only 750 acres. Evidently intensive forestry even approaching that of Germany will not be possible in the National Forests until the size of the working area is materially reduced. At present even adequate protection is impossible, and correct technical management of the forests still more so.

Another difference between the German and American systems of administration is the greater division of work in Germany. There the technical, constructive, fiscal, legal, and police work necessary in forest administration are usually kept distinct; in this country the technical, constructive, and police work not infrequently have to be done by the same men. The result is that all three lines of work more or less interfere with each other, with consequent loss of efficiency.

In the matter of technical forest education, the German Government exercises a more direct influence than does the United States Government. In Germany the technical forest schools are conducted directly by the State, while in the United States the forest schools are all connected with private or state institutions. The Federal Government has no direct control over any of them. It has recently, however, made arrangements for giving instruction to rangers in cooperation with private institutions, and to this extent is following the lead of Germany, where ranger schools are well established. The Germans insist on a more thorough technical training for all of their forest officers than is required here, and no one is put in charge of technical forest work who has not had a thorough technical training.

In the dissemination of popular information concerning forestry the United States compares favorably with Germany. All available information of value is published promptly in the form of readable circulars, and the Government assists in educational work by furnishing speakers, by lending lantern slides, and by outlining methods of instruction.

FRANCE.

While France has not yet succeeded in developing such intensive forest methods as Germany, it has nevertheless clearly recognized the necessity for conservation of its timber resources, and its experience in reforestation is of particular interest to this country. By the middle of the seventeenth century the progress of forest destruction had reached such a point that Louis XIV's great minister, Colbert, remarked, "France will perish for lack of woods." The forest ordinance of 1669, which was passed through his influence, was a great step toward forest regulation, and, with the exception of the years during the French revolution, continued in force until the passage, in 1827, of the Code Forestier, which, with certain revisions, is the law of the present day. It is thus seen that while France early recognized the necessity of preserving its forests, the development of a satisfactory forest policy was comparatively slow.

The growing scarcity of timber was the cause of the first steps toward forestry, although the necessity of preserving the forests for

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the protection of watersheds and the water supply had a much earlier and much stronger influence than in Germany. As early as the sixteenth century the local parliaments enacted decrees against clearing in the mountains, but during the revolutionary period these restrictions vanished, the mountains were stripped of their forest cover, and tremendous damage resulted. The first work of recovery was begun in 1843, but owing to political events did not progress very rapidly until 1860, when the passage of a special law charged the forest department with the mission of extinguishing the floods. In 1882 this act was amended, so as to place the entire cost of the work on the State. Out of the 1,462 brooks and mountain streams which are considered dangerous in the Alps, Pyrenees, and Cevennes, 163 had in 1893 been entirely controlled, and 654 had begun to be "cured." Among the former were 31, the control of which fifty years ago was considered by engineers to be impossible. This probably furnishes the best practical example of the disastrous effects which follow deforestation in the high mountains and of the possibility of controlling torrents by afforestation.

In France the total forest area covers only 18.2 per cent of the total land area, and the forest area per inhabitant is 0.61 acre, precisely the same as for Germany. Although the annual consumption is only 24.6 cubic feet per inhabitant the supply is insufficient, and France is, next to England and Germany, the largest wood-importing country in Europe. This deficiency in the timber supply has not led to overcutting, however, and France, like Germany, has clearly recognized the fundamental principle that the annual cut must not exceed the annual growth. This in France is 37.9 cubic feet per acre, which, although high in comparison with the growth in the United States, is rather low compared with that in Germany. This is due partly to the less intensive management practiced in France and partly to the composition and character of the forest. Of the total forest area only 20 per cent is stocked with conifers, while 80 per cent is stocked with hard-wood stands, many of which are of sprout origin. Efforts are now being made to better the forest by converting sprout stands into seedling stands and by increasing the percentage of conifers.

In the development of a silvicultural practice the French have made considerable advance, but have not attained the perfection reached in Germany. An unfortunate tendency has been to stick to one system of cutting, regardless of conditions, and to make arbitrary marking rules. The result has been to deprive the local forest officers of any spirit of initiative and to force the adoption of certain set methods regardless of their applicability. The methods used were wholly of empiric origin until the necessity of introducing experimental methods was recognized by the establishment in 1882 of a forest experiment station at Nancy.

The greatest advances in forestry made by the French have been in developing new ideas regarding thinnings and in the work of reforestation. During the last century over 2,500,000 acres have been reforested, mainly in the mountains and in the sand dunes, marshes, and limestone wastes. The sand dunes along the coast of France, chiefly in Gascony, were formerly covered with forests, but by the destruction of these were turned into barren wastes. As early as 1717 small attempts at reforestation were made, but work was not taken up on a large scale until the last century, since which time 275,000 acres

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of moving sand have been fixed by plantations of pine. East of the dunes stretch the Landes, an area containing 2,000,000 acres of shifting sands and marshes. From 1850 to 1892, 1,750,000 acres of these were drained and successfully planted to pine at a cost of from $4 to $5 per acre, and a recent estimate places the value of this territory at $100,000,000. Between the valleys of the Loire and the Cher lies the region of La Sologne, a sandy, poorly drained plain upon an impenetrable calcareous subsoil. This region was originally densely wooded, but by 1787, 1,250,000 acres had become absolutely abandoned as a result of deforestation. Over 200,000 acres of nonagricultural lands have now been reclaimed by plantations of Scotch and mountain pine. Lands which fifty years ago could hardly be sold for $4 per acre now bring an annual revenue of over $3. In the province of Champagne 200,000 acres of arid limestone wastes have been reforested, mainly with pine, and now yield a net revenue of $2 per acre. The successful attempts at reforestation and controlling the torrents in the mountains have already been mentioned.

The results obtained in France along these lines are of special interest to the United States, where there is also much waste and deforested land which will never be valuable except for forest purposes, and which requires planting to restore the forest cover. France has proved that even arid wastes can be successfully planted and made to yield a net revenue.

The money returns from French forests resemble the wood returns in being less than is the case in Germany. In 1902 the state forests of France yielded a gross revenue of $2.45 and a net revenue of $1.47 per acre. A striking fact in this connection is that the present yield is actually slightly less than it was forty or fifty years ago. This is probably due to the fact that the condition of the forests has not improved materially during that time, and particularly to the fact that the forests are now largely composed of broadleaf species which, since they are to a great extent in poor condition, yield an abnormally low percentage of saw timber. The yield is, nevertheless, in striking contrast to the net returns of $0.005 per acre in the United States, where the species are, as a rule, both more valuable and more rapid growing. This is due partly to the higher prices and better market conditions, but far more to the greater care bestowed upon the forest. The expenditures equal about one-half the gross receipts, and, as in Germany, both the gross and net receipts show a noticeable increase with increase of expenditures. Although the forest has been under administration for many years, nearly 25 per cent of the total expenditures is still devoted to permanent improvements. In the United States, on the other hand, permanent improvements, which are essential to the proper administration of the forests, receive less than 5 per cent of the total expenditures.

As in all European countries, the State takes an important part in the management of the forests. Only 12 per cent of the forests is under state ownership, but the State also exercises a controlling influence over all of the communal and many of the private forests. In general, the state and communal forests show better returns than those under private management. The State exercises an even greater control over the communal forests than in Germany. Private owners, however, are free to manage their forests as they please, except in the case of protection forests necessary to prevent erosion, to

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maintain the water supply, or prevent the drifting of sand in dunes along the coast, or for the benefit of the public health. In all of these cases the State reserves the right to prevent the clearing of the forest and to prescribe the system of cutting. The State encourages cooperation with private owners, and is ready to undertake the management of private forests when requested to do so by the owners.

Much trouble has been experienced in the management of the state forests by the existence of rights of user, similar to those in Germany. These proved to be such a hindrance that in 1827, on the passage of the Code Forestier, a systematic plan was made to extinguish them, and the work may now be considered practically complete.

The administration of the state forests is under the minister of agriculture as president of the forestry council, with the director-general as vice-president and technical head. The central office also comprises three administrateurs verificateurs généraux, as chiefs of the three bureaux into which the administration is divided, each with two chiefs of sections, inspectors, and the necessary office staff. For purposes of local administration the forest area is divided into 32 districts, each under the charge of a conservateur, who corresponds to the German oberforstmeister. These are again subdivided into a number of cheffries, or inspections, which are administrative units, under inspectors and assistant inspectors, corresponding to the oberforster in Germany and to the supervisor in the United States. The actual forest work is done by gardes généraux, with the assistance of gardes généraux stagiaires, corresponding to the German forster and to the American rangers. These officials comprise the superior service, which is kept very distinct from the inferior service, composed of underforesters (brigadiers), or guards, and other workmen, corresponding to enlisted men in the army. The system evidently corresponds quite closely to both the German and American systems of administration.

France has only one forest school where higher technical education can be obtained. This school was established by the State in 1825 at Nancy, and in spite of various unfortunate experiences, has continued to the present day. It is intended primarily for the training of state foresters, and only 12 students are allowed to graduate annually, although foreigners and others who are not seeking state employment may study there. At Barres the State maintains two lower grade schools, one of secondary and one of primary instruction, for the training of forest guards. The superior service is composed of technically trained men, although these officials are not as a rule so thoroughly educated as in Germany. The opportunities for forest education in the United States and the part taken by the Government in spreading general information concerning forestry to the public compare favorably with France.

SWITZERLAND.

Switzerland is of interest because it is a republic, somewhat similar in form to the United States; because it shows intensive forest management, with high returns; and because it has developed an efficient system for the protection of its mountain forests.

The forest area occupies 21.2 per cent of the total land area. The forests are very irregularly distributed in the different cantons, but

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are present everywhere in the high mountains. A striking fact concerning them is the great number which are under communal ownership. Sixty-six and nine-tenths per cent are owned by communes and corporations, 28.8 per cent by private individuals, and only 4.3 per cent by the cantons, or States; the Bund, or Federal Government, does not share in the ownership of any of the forests, although it does take an important part in their management.

The forests are separated into protection and nonprotection forests, the former being such as are located at headwaters of streams or furnish protection against snowslides, landslides, floods, or climatic damage. All protection forests, whether public or private, are under federal surveillance, and must be surveyed and their bounds permanently marked. Their management is so regulated as to secure a sustained yield according to working plans sanctioned by the Federal Government; fellings must be made under the direct supervision of a trained forester, and clearing the forests is prohibited except by permission of the Federal Government.

All communal forests are subject to general supervision by the cantons. In nonprotective private forests the owner is free to manage his property as he pleases, with certain restrictions. Clearing is prohibited except by permission of the cantonal government; felling areas must be reforested within three years, and existing pasture woods must be maintained. Wherever protective forest areas can be created by the reforestation of waste land, this may be ordered, and either the Federal or the cantonal government contributes toward the expense of the reforestation. The law encourages the cooperative forest management of small holdings, the Bund paying for the cost of effecting such cooperation; it also empowers the Bund or the canton to enforce such cooperative management in specially endangered localities, as at the headwaters of torrential streams. This system of cooperation has been very successful, and the general system of federal supervision has met with excellent results. Torrents have been checked and controlled, and excellent financial results have been obtained. Planting has been resorted to in order to extend the forest area, particularly in the mountains, and the forest area has actually been increased 10 per cent in the last fifteen years.

For Switzerland as a whole the annual growth reaches the high average of about 51 cubic feet per acre. This also equals the annual cut, since Switzerland, in common with France and Germany, cuts only the annual growth. As usual, the state forests show the highest yields. During the four years prior to 1893 the average cut of the state forests was over 64 cubic feet per acre, while that of the corporation forests was only 42 cubic feet.

The money returns vary widely, averaging for most of the cantonal and communal forests between $3 and $9 per acre. In 1903 the net receipts of the town forest of Winterthur reached $11.69 per acre. The Swiss forests are thus seen to yield exceptionally high returns, partly on account of good prices and ready markets and partly on account of highly developed silvicultural practices. From 1895 to 1899 the average stumpage price for both timber and firewood was 6.3 cents per cubic foot—about the same as in Prussia. In the low country, however, wood prices are higher than the average in Germany, and coniferous saw material brings prices of from 12 to 15 cents per cubic foot.

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Silvicultural practices are well developed and nearly all of the forests are managed under working plans. The Federal Government in 1855 instituted a two-year course in connection with the Polytechnikum at Zurich for the education of the higher forest officials, and in 1884 the course was increased to three years. In connection with the school at Zurich is a central forest experiment station, with several substations, where thorough scientific investigations of practical problems are pursued, the results of which have proved of great value in forest management. The cantons also give short courses for the education of the lower-grade foresters.

Switzerland repeats the history of other countries in having done but little for the preservation of its forests until forced to do so by circumstances. The first working plan seems to have been made for the Sihlwald, the city forest of Zurich, in 1680–1697; and the Bernese cantonal forests were first surveyed and placed under management from 1725 to 1739, and were fully regulated by 1765. These first efforts at establishing a forest practice were not general, however, although by the beginning of the eighteenth century the growing scarcity and increasing value of forest products had called attention to the necessity of protective measures.

Fears of a timber famine had previously caused a number of cantons to attempt to prevent further decrease of the forest area, but not until the severe flood of 1830 emphasized the protective value of a forest cover were these ordinances strictly enforced and a general movement for the better begun. The increase in torrential floods hastened the movement, and resulted in the delegation to the Federal Government of power to regulate the use of the protective forests. Forestry in Switzerland, then, was at first a result of the growing scarcity of timber, but did not develop rapidly until the severe floods resulting from the destruction of protection forests in the mountains forced the necessity of their preservation on the people. Rapid strides have since been made, and Switzerland has succeeded in proving beyond question that forestry can be profitably conducted, and that the use of protection forests can be satisfactorily superintended so as to maintain their productive capacity without lessening their protective value.

AUSTRIA.

Austria is of particular interest because forest conditions more closely approximate those in the United States than do those in any other of the countries considered. Austria shows variable forest conditions in different parts of the country, with considerable areas of virgin forest in the mountains; private ownership is more extensive than elsewhere in Europe, and the state forests are only now being thoroughly organized.

The forest covers 32.5 per cent of the total land area, with 0.91 acre of forest land per inhabitant. This large forest area enables Austria to be one of the few wood-exporting countries of Europe. This export is largely at the expense of the forest capital, however, since the annual cut varies from 60 to 67 cubic feet per acre, while the annual growth is only 42.4 cubic feet. This high yield for a country which is relatively undeveloped as compared with Germany, France, and Switzerland, is due partly to the fact that the forest is

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composed mainly of conifers (82 per cent), and partly to the fact that rapid strides have been made toward conservative forest management within the last fifty years.

In the northwest provinces, such as Bohemia, Moravia, and Silesia, where the population was denser than elsewhere, and where the influence of Germany was most strongly felt, the forests were early taken care of and forest management well developed. German methods were largely followed, and in some places almost model forests were in existence as early as 1848. In the more inaccessible mountain districts, however, the forests were for a long time neglected, and it is only within the last fifty years that material progress has been made in bringing them under management.

The state forests comprise only 7.3 per cent of the total forest area, and lie mainly in the more remote mountain districts. Twenty-six per cent lies in the plains and foothills, 49 per cent at medium elevations in the mountains, and 25 per cent in the highest mountain region up to the limit of tree growth. This region is largely undeveloped and inaccessible, so that for twenty years from 1874 to 1893 the annual net returns amounted to only 26.8 cents per acre. This is in striking contrast to the high returns in the more thickly settled European countries to the north and west. It is also in equally striking contrast to the net returns of 0.5 cent from the National Forests in the United States, where conditions are somewhat similar to those in Austria. Working plans have been prepared for most of the state forests, and by 1898 nearly 82 per cent of them were under regulated management. The silvicultural systems employed are largely based on those in use in Germany. They are, however, less intensive, are better adapted to the sparsely populated mountain districts in which most of the state forests lie, and are therefore more applicable to conditions in the United States.

One of the most difficult problems which the State has had to solve is the reforestation of the "Karst," a dry limestone waste lying in the mountain and hill country of Istria, Trieste, Dalmatia, Montenegro, and adjacent territory skirting the Adriatic Sea. This area was originally well forested with conifers and hard woods, but through reckless cutting, burning, and pasturing was reduced to a barren waste. Attempts to reforest it have not been wholly successful, and much remains to be done. A small portion of it has been planted and a considerable area reforested by protective measures, particularly by the exclusion of goats. Enough has been done to prove that the waste can be restored to its original forested condition, although at the expense of much time and money.

The private and communal forests are not so well managed as those belonging to the State, but great improvement has been shown in their management in the last twenty-five years, and more and more of them are being brought under the regulation of approved working plans. According to the general rule in Europe, all protection forests, including those under private ownership, are under state supervision, and cutting in them is carefully restricted. No forest can be absolutely cleared away without permission, and private owners may be compelled to restock blanks in their forests if these have a protective value. A unique feature of the relation between the State and private owners lies in the so-called "forest protective service." The severe floods of 1851 called attention forcibly to the necessity of

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forest protection, and an organization was created to manage the state forests, supervise the management of corporation forests, and afford police protection to both. In 1883 the functions of this service were extended "to instruct and encourage forest owners in forest culture, and to manage forests so designated to be managed." This service has proved so satisfactory that owners have freely availed themselves of it, and now ask constantly for its extension. It has succeeded in bringing about extensive cooperation with private owners, and about 60 per cent of the Austrian forests are now managed under working plans.

The organization of the state forest administration is much as in Prussia. The forest service is in the department of agriculture, with an oberlandforstmeister at its head. The country is divided into a number of inspection districts in charge of oberforstmeister and forstmeister. These are further subdivided into working areas under oberforster, with the assistance of "forstwarte" as executive officers. The average size of a district under an oberforster is 452,762 acres, which corresponds more closely to the size of an area under a supervisor in this country, although still but half as large. There is a more marked contrast in the area under the management of a single local officer. The average size for this in Austria is 13,880 acres, as against more than 100,000 acres under a single ranger in the United States.

There are a number of forest schools in Austria for the training of both of the higher and the lower grades, and an excellent state school at Vienna. There are also a number of forest experiment stations in the country, which have done much for the advancement of forestry.

CONCLUSIONS.

This brief review of foreign methods of administration brings clearly to light certain facts which can well be used in developing methods of forest administration in this country, and which it may be well to summarize here.

The experience of foreign countries has invariably proved that evil results follow if the forest is neglected and recklessly exploited until its preservation and protection is made absolutely necessary by fear of an impending timber famine or by disastrous floods. Many years and great expense are required to restore the forest to its normal productive capacity, whereas this capacity might have been greatly increased at much less expense of time and money if steps had been taken early enough.

The Europeans have also proved not only that forestry is necessary if the forests are to yield the best results, but also that it is profitable. The more intensive the forestry practiced the greater, as a rule, are both the wood and the money returns. The more that is spent upon the forest per acre the greater are the net returns received from it. Economic conditions in this country at present do not permit in many places of as intensive methods as are possible in Europe. The principles involved are applicable at once, however. Measures for forest preservation should be taken before it is too late; waste should be reduced to a minimum, more money should be spent on the forest in order to increase net returns, and above all the an-

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nual cut should be limited to the annual growth in order not to deplete the forest capital.

Foreign silvicultural methods are not usually applicable without change, but the general systems have been adapted with success to conditions in this country, and should be still more widely used. The important point to be recognized in avoiding the mistakes made abroad is that hard and fast, arbitrary rules seldom yield good results, and that the system adopted must be elastic and adapted to specific conditions. France, in particular, has proved that barren wastes and denuded mountain slopes can be successfully reforested, and this system of reforestation is as applicable in this country as there. Wholly empiric methods of forest management have invariably failed to yield the best results, which can be obtained only by systems based on carefully conducted experiments and thorough research work. Forest experiment stations are, therefore, a necessity if forestry is to reach its highest development.

A striking point concerning forestry abroad is the important part taken by the State in the management of communal and private as well as of state forests, and the considerably greater returns obtained under state management. All communal forests are subject to some form of state supervision, and many of them are managed precisely as if they were state property. Private forests necessary for the protection of watersheds or the welfare of the general public are also subject to state control; they can not be cleared, cutting must be done as prescribed by the State, and all cuttings must be reforested. Other private forests not necessary for protective purposes can usually be managed as the owner desires, but cooperation with the State in the management of such forests is common, so that the State also exercises a large influence in the management of private forests. State management is the most stable and efficient, and almost invariably yields the best results. There is apparently no sufficient reason why this should not also be the case in the United States. Government supervision of protection forests, where necessary for the welfare of the public, can hardly be considered as unwarranted encroachment on private rights, and might well be adopted here. More extensive cooperation between private owners and the Government in the management of other private forests would also undoubtedly yield good results and should be encouraged as much as possible. Communal forests have arisen in Europe as a result of the economic development of the country, but they have given such excellent results there and have proved so profitable that it would seem as if similar town and city forests could be advantageously established in the United States.

In general the organization of the Forest Service for the administration of the National Forests in the United States is similar to that in most European countries. The most noticeable differences lie in the much greater area under the administration of a single executive officer in the United States and in the lack of technical training in many of the men engaged in technical work. The forests can never be properly protected nor cared for until the working areas are so reduced in size that a man can adequately care for his district, and until a thorough technical training is required of men engaged in technical forest work.

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At present the results of forest administration in the United States do not compare favorably with those attained in Europe. This is largely due to economic conditions, which have made impossible the development of very intensive forest practices, and to the lack of public interest in forestry and failure to realize its necessity and practicability. There is no good reason why this should continue, and no reason why the United States should not secure in time fully as good results as are now obtained in Europe. Forestry in this country is still young and time is necessary for its development; but this development can be hastened and guided by using the experience of European countries and by adopting, so far as conditions warrant, those methods of administration which have proved successful there.

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FOREST FIRES.

By CLYDE LEAVITT,
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SUMMARY.

Fire is the greatest enemy of the forest. The lack of reliable statistics is the greatest obstacle to the securing of effective measures for fire prevention and control.

DAMAGE FROM FOREST FIRES.

More than 2,000 people perished in forest fires in the United States in the nineteenth century. During the past thirty-seven years there has been an annual average of 50 deaths from this cause.

The value of the standing timber destroyed has varied from $25,000,000 to more than $100,000,000. The direct annual loss has averaged $50,000,000.

The destruction of the young growth, though never included in estimates of fire damage, is a principal item of loss. The natural restocking of burned-over lands takes place very slowly or not at all. Had fires been prevented on nonagricultural lands now unproductive because of forest fires, 32,000,000,000 feet of timber, valued at $64,000,000, would now be produced annually on this land. The amount of this loss is equivalent to 80 per cent of the total lumber cut of the United States, or 32 per cent of the total consumption of wood material of all kinds.

Not less than 20,000,000 acres of young growth are burned over annually. At $10 per acre, the cost to replant is $200,000,000. Repeated fires have totally destroyed the forest over immense areas of nonagricultural lands and rendered the restoration of forest conditions possible only by artificial planting at great expense. Even where the forest has not been destroyed, its composition over immense areas has been changed for the worse.

In mountainous regions, deterioration and erosion of the soil, due to forest fires, cause a loss that is in many cases greater than that resulting from the destruction of the stand of merchantable timber and of young growth.

The destruction of the forest by fire results directly in an impairment of the regularity of stream-flow, tending to cause an alternation of flood and drought. Thus are brought about great losses to irrigation, water power, navigation, and other interests.

Fires, by reducing the available supply of raw forest material, have increased the cost of all forms of forest products.

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The forest, if properly protected, is a reproducible resource; to be treated as a crop, differing from ordinary farm crops only in the time element. Under present conditions, the forest is exhausted, like the mine. The lumber industry is nowhere on a permanent basis, but has moved steadily West or South. This is true also of the naval-stores industry.

The power of the community for development through taxation is decreased by forest fires, since taxable property of great value is destroyed. This in turn is reflected in a general lowering in the values of all remaining forms of property.

CAUSES OF FOREST FIRES.

The principal causes of forest fires in the West are railroad locomotives, campers, and lightning. In the East and Middle West the principal sources of danger are the clearing of land and sparks from railroad locomotives. In the South practically all the forest fires are set intentionally, the greater part of the forest area being burned over annually.

In general, the great majority of fires are due to carelessness and ignorance.

FIRE PREVENTION AND CONTROL.

Damage by forest fires is practically preventable. In the United States, however, the people as a whole have never realized that fire protection is sufficiently desirable to make it worth while, or that it is practicable as a sound business measure.

Preventive measures are (1) administrative; (2) legislative; (3) educative. The aim of the second and third is to secure adoption of the first.

Of administrative measures, the most effective are patrol, brush burning, fire lines, back firing, the construction of roads, trails, and telephone lines, and the use of lookout and observation towers. Of these the one most vitally essential is patrol.

Legislative measures have in general been inadequate on account of lack of enforcement. A strict enforcement of existing laws would go far toward removing ignorance and indifference.

The present tendency toward replacement of coal by the use of electricity or petroleum as motive power on railroads traversing forest lands offers the greatest encouragement for the future.

Educative measures are of primary importance, because it is through them that the adoption of administrative and legislative measures is secured. The most effective is the dissemination of information concerning the causes and effects of forest fires and the methods by which they may be prevented or controlled.

RESULTS ACCOMPLISHED BY THE FEDERAL GOVERNMENT.

The national forests, though undermanned, offer the best example in the United States of an efficient system of fire prevention and control. In 1904 the area burned over was 0.66 of 1 per cent of the total area of the forests, exclusive of Alaska and Porto Rico; in 1905, 0.31 per cent; in 1906, it was 0.094 per cent; and in 1907, 0.14

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per cent. The value of merchantable timber destroyed in 1907 was only 40 per cent of that burned the preceding year. The merchantable forest burned over in 1907 represented but 0.02 of 1 per cent of the national forest area.

The Forest Service cooperates with States and counties and with private owners and railroad companies for better fire protection on the national forests and on areas adjacent, the burning over of which would be a menace to the forest property of the Government.

On military reservations and national parks damage by fire is reduced almost to a minimum on account of the presence of federal troops. On Indian reservations until very recently practically no steps have been taken to prevent the occurrence of fires or to control them after starting. As a result there has been immense loss. On the public domain no steps whatever are taken to prevent or control forest fires.

RESULTS ACCOMPLISHED BY STATE GOVERNMENTS.

The action taken by States has been altogether inadequate. The best results have been accomplished in New York, New Jersey, Pennsylvania, Wisconsin, and Minnesota. More state forests should be created, and protected and administered at state expense.

RESULTS ACCOMPLISHED BY PRIVATE OWNERS.

On probably not more than one per cent of the 450,000,000 acres of forest lands in private ownership in the United States is there a system of fire protection in which the object sought, and for the most part accomplished, is the prevention of fires rather than the mere control after the fires have actually begun.

INTRODUCTION.

Of all the enemies of the forest, fire has without exception been the most destructive and far-reaching in its effects. Forest fires have occurred since the earliest periods of which we can gain any record. That disastrous fires were started by natural causes in the earliest history of the country can not be questioned. That with the advent of man the damage has vastly increased is equally true. Without adequate protective measures there is no question that the risk from fire on forest land would continue to be greater, year after year, as the country is opened up by railroads, and clearings are made by settlers, and as timber is cut by the logger. All experience goes to prove that fire follows the railroad, the settler, and the lumberman. Occasionally large forest fires occur which assume the proportions of national disasters, and public sympathy is temporarily aroused for the immediate sufferers. Such a fire was the one which occurred during the first days of August, 1908, in the mountains south and southeast of Fernie, British Columbia. The death loss from this fire was 18 people and the value of timber and other property destroyed was more than $6,000,000, and 6,000 people were made homeless.

Fire had been reported as burning on cut-over lands near Fernie for some time previous to the disaster, but until a heavy wind sprang up and caused the rapid spread of the flames no attention was paid to

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it and no attempt made to extinguish it. According to the newspaper report, it was commonly supposed that "the fires were doing no damage." This state of mind is typical of what has long been the attitude of the great majority of the American public toward the fire problem. Some progress has been made toward overcoming this point of view, but the results, as expressed in concrete form, have been pitifully inadequate. The damage from forest fires in the United States amounts annually to many million dollars and occurs in many different forms. The greatest obstacle to securing the adoption of adequate measures for the prevention and control of forest fires has been the almost total lack of reliable statistics of fire loss. It can hardly be conceived that remedial measures could long be delayed were the people as a whole fully informed of the incalculable economic loss that is being sustained each year from this source, and of the beneficial results that could be obtained by the expenditure of comparatively small sums in protection. For only a very small percentage of the forest fires that have occurred, even in recent years, has any attempt at an estimate been made.

Outside of the loss of buildings and personal property, the only item ever taken into consideration in estimating fire loss has been the single one of standing merchantable timber. Other items, frequently of far greater importance, but more difficult to estimate, have been overlooked entirely. Since no attempt has ever been made to secure accurate information as to the loss of standing timber, the estimates have almost without exception been far under the actual facts. A good illustration of this is the loss resulting from the severe fires in the forests of the northern peninsula of Michigan in 1906. It was stated by the commissioner of one of the railroads that of 250,000 acres in a single district along his line there was not a square mile within which fire did not appear. Severe fires occurred at the same time in six or more counties, yet the state fire warden placed the total loss at only $100,000, notwithstanding the fact that the losses were largely in perishable hard woods—maples, birch, etc.—which decay so rapidly that a satisfactory exploitation of these fire-killed woods is almost impossible. A local estimate placed the loss at $250,000. If, however, it be considered that an average acre in that region bears a stand of 5,000 feet b. m., with a stumpage value of $5 per 1,000, it will be seen that in order to cover even the latter estimate only 10,000 acres, or less than half a township, need have been burned over. The actual stumpage loss to the State from forest fires during 1906 is estimated by Prof. Filibert Roth, state forest warden, as being not less than $5,000,000, and probably far in excess of even that figure. The difficulty of securing accurate data as to fire losses will be readily admitted, since without a careful examination neither the area burned over nor the amount of timber destroyed can be determined. The information is, however, of great public value. It can not be expected that it will ever be satisfactorily furnished by private individuals or corporations. It is exceedingly desirable, therefore, that action be taken by the state and federal governments to this end. It is suggested that an attempt be made by the National Conservation Commission to secure the adoption of measures which will result in the uniform collection throughout the United States of statistics of this kind.

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The time is rapidly approaching when the adoption of adequate measures for the preservation and perpetuation of our forest resources will become economically imperative. At the present time, however, stumpage prices are for the most part low, and the general adoption of any complicated system of forest management can hardly be expected. The soil and climatic conditions in the United States are, however, generally favorable to forest growth, and if protection from fires can be secured nature alone will accomplish a very great deal.

(A) DAMAGE FROM FOREST FIRE.

The damage done by forest fires may be classified under the following heads:

1. Loss of life.
2. Destruction of merchantable standing timber.
3. Destruction of young growth.
4. Effect on the distribution and composition of the forest.
5. Deterioration of the soil.
6. Injury to stream flow.
7. Injury to general business interests.

(1) LOSS OF LIFE.

More than two thousand people perished in forest fires in the United States in the nineteenth century. There have been a few great historic fires which have attracted general attention and are well known for the wide territory they have covered and the thoroughness of the destruction.

The most memorable forest fires which have occured are those in Wisconsin in 1871, in Michigan in 1881, and in Minnesota in 1894.

Forest fires raged in the northeastern part of Wisconsin in the latter part of September and first part of October, 1871, particularly in the counties on both sides of Green Bay. Four hundred square miles of territory were entirely devastated. Of several villages wiped out of existence, the principal one was Peshtigo. Governor Fairchild in a proclamation stated that the loss of life in the devastated district was at least 1,000, and 3,000 people were left entirely destitute.

The theater of the great forest fire in Michigan September 5 and the following days, 1881, was in the broad peninsula between Lake Huron and Saginaw Bay in the southeastern part of the State. The fire ran over 48 townships, a belt of timber country 60 miles in length, north and south, by from 10 to 30 miles in width, and comprising 1,000,000 acres. The number of people who perished was 138.

The village of Phillips, Wis., was burned by a forest fire July 26, 1894. Thirteen lives were lost and very much timber and other property destroyed.

In September, 1894, occurred the terrible Hinckley fire (Minnesota), in which 9 towns were destroyed and more than 600 people perished. Over 2,000 people were left destitute, and $25,000,000 worth of property was destroyed.

In September, 1902, forest fires in Oregon and Washington cost 18 lives and resulted in the destruction of timber and other property valued at more than $12,000,000.

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Conditions during the year 1908 have been worse with regard to forest fires than for many years past. In British Columbia in August occurred the Fernie fire, already mentioned, where 18 people lost their lives. On October 16, near Alpena, Mich., 17 people perished while trying to escape from the little town of Metz, Presque Isle County. The town had been surrounded by forest fires which were closing in from all sides. A relief train was sent in order that the citizens of the town might escape. Two miles south of Metz the engineer saw blazing piles of cedar ties on each side of the track which had caught fire from the adjacent forest. Opening wide the throttle, he tried to dash through at full speed. About half way through the blazing ties the rails had been loosened by the heat, and the 5 cars and locomotive ran on the road bed until they came to a stop. In a moment the locomotive and cars caught fire, with the result that 17 known deaths occurred and many were severely injured by burns. Many towns through the Middle West have been threatened with destruction during the past season and a not inconsiderable number have been wiped out entirely. The complete destruction of the town of Chisholm, Minn., in September is a good example of this. No complete statement of the total number of deaths is possible. In Michigan alone, during the fire season of 1908, not less than 35 people lost their lives as a direct result of forest fires.

(2) DESTRUCTION OF STANDING TIMBER.

Large fires, such as those above described, have been comparatively few in number and of infrequent occurrence. From the earliest times, however, small fires have every year destroyed standing timber to the value of many millions of dollars, and it is these which are principally responsible for the vast aggregate of our loss from this source. The story of these fires is written in every feature of the forest, in the character of the soil and its cover, in the composition of the forest, and in the individual trees themselves.

The destruction of standing timber may occur in any one of the three following ways:

(*a*) By the killing of the timber, usually through ground or surface fires. Until within comparatively recent times but little attempt has been made toward the utilization of fire-killed timber, especially in the Western States. The worst fires have occurred in the more inaccessible regions, mainly owing to the fact that in such regions men were not available to stop the fires before they had burned themselves out. Under these conditions the utilization of dead material is clearly impracticable. Areas once burned over and on which the timber has been killed are generally more subject to later damage by fire than areas on which the timber is living. As a result of fire many trees fall to the ground after a time and furnish fuel for later fires. In many cases the same area is burned over repeatedly, the later fires destroying all the remaining seed trees which at first escaped. The result is in general a dreary, blackened waste which can be made to produce revenue only by the expenditure of large sums in forest planting.

(*b*) Injury to the individual tree. Light surface fires are frequently regarded as harmless. This, however, is far from being true,

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for in addition to destroying the young growth, surface fires injure many trees to such an extent that complete recovery is impossible. Through the burning of the bark at the base of the tree the inner layer of growing tissue is exposed to the air and in many cases becomes infected with fungous diseases through the spores which are generally plentiful throughout forest regions. As a result rot or dote occurs, and the value of the tree is partially or wholly lost by the time it reaches maturity. Younger trees are greatly reduced in value through the destruction of the fiber by the fungus, rendering it necessary to cut high stumps or to "butt off" a portion of the first log. The damage is especially great in the case of thin-barked species, as lodgepole pine and the spruces and firs. Western yellow pine and other species having a thick bark are comparatively unaffected by surface fires.

One of the best examples of the injurious effects of repeated grass fires on individual trees is seen in the longleaf pine forest of the South, where turpentining operations are carried on. In a virgin unboxed pine forest the damage to the tree is very slight. Perfectly sound trees seem to suffer not at all. Those on which the bark has been broken by natural causes or by chipping, to see if the grain is straight enough for rails, are slightly injured by fire igniting and charring these exposed places. As soon, however, as the trees are boxed the danger increases. During the period of operations the trees are protected by the raked circle at the base. As soon as the orchard is abandoned the raked space becomes covered with litter, and fire is easily communicated to the box and excoriated surface. The exposed face is covered with resin and the box is usually well filled with gum, both substances being highly inflammable. When flame is communicated to a box the resulting fire is of no mean importance. Not only does the resinous surface burn, but the heat is so intense that the flames, fed by the melting resin, shoot up the side of a tree, often for 25 feet. The spectacular part does not last over ten to fifteen minutes, but the box and base of the tree often continue burning for hours. To see a box burn one would not believe that the tree could survive, especially as two boxes often burn out on one tree, but it seldom happens that a tree is killed outright. The bark is wonderfully resistant and does not ignite or conduct heat even under the fiercest flame. The bark stripped off along the edge of a recently burned box is cool on the inner side, except on the very edge next to the fire.

The damage comes not from one fire, but from repeated fires. Each year the burned box and face on a tree is charred a little deeper, until at last it is burned entirely through at the base or so weakened as to allow the tree to be easily toppled over by the wind. Even if the trees live and stand there is no opportunity for them to heal over the wound, while, in addition, the removal of the antiseptic covering of wax gives access to insects and spores of fungi.

Lumbering usually follows the "turning loose" of a turpentine orchard, so that the two combined make conditions even worse. The slash furnishes fuel for hotter fires, while the opening up of the forest results in more "blow downs."

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The injury to individual trees depends upon the severity of the fire, and this in turn upon the amount of grass, humus, or débris upon the ground. Many cases occur in which the vitality of the tree is injuriously affected without killing it outright. In such cases the tree is rendered much more subject to attacks by insects, such as bark beetles, than would be the case had it retained its vigor. In vigorous trees the presence of insects generally does comparatively little damage, unless they are present in great numbers. Under ordinary circumstances the number of insects is kept down by the copious flow of pitch, by which many of them are drowned. When the vitality of the tree, however, is weakened through the occurrence of fire at its base, the flow of pitch is lessened, the power of the tree to resist its enemies is partially destroyed, and it becomes much more subject to insect infestation than would otherwise be the case. Western yellow pine (*Pinus ponderosa*) is particularly subject to injury by bark beetles, though injury of this kind is not limited to any genus or species. When the beetles become so numerous that their galleries practically or completely girdle the tree under the outer bark, the death of the tree follows. Trees affected in this way become centers of infestation, from which new swarms of beetles spread and bring about the similar destruction of other trees. Very large areas of timber in the Rocky Mountains and in the Black Hills have been destroyed in this way. Insect-infested timber is usually sold at a large reduction, in order to encourage immediate utilization, and thus prevent further infestation. Unless cut within two or three years the quality of the timber becomes seriously impaired by rot, but if cut immediately the quality is not affected. Many areas of infested timber can not, however, be lumbered, unless at a distinct loss, on account of inaccessibility. There is no question but that forest fires, by rendering trees more subject to insect infestation, have resulted in the absolute loss of vast quantities of timber and in the partial loss of additional large amounts. No estimate of this loss has ever been made or can be made with any degree of accuracy.

(*c*) The third way in which timber is destroyed is through the complete burning of the timber itself. The loss here is, of course, absolute.

The actual amount of stumpage destroyed by fire can, of course, never be known. That it is appallingly large is conceded by all, and it is no exaggeration to state that more timber has been destroyed by fire than by the ax since the settlement of this country. According to an estimate based on the census figures, over 700,000,000,000 feet b. m. have been cut for lumber between 1880 and 1906. Unquestionably the amount destroyed by fire has been much greater.

The census for 1880 gives the area burned over during that year by forest fires as over 10,250,000 acres, with a property loss of over $25,000,000. This estimate is a very conservative one, since all unreliable or contradictory returns were absolutely disregarded. The following is the detailed statement:

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Table of forest fires occurring during the census year.

[Tenth Census of the United States, volume 9, 1880.]

States and Territories.	Areas burned.	Value of property destroyed.	States and Territories.	Areas burned.	Value of property destroyed.
	Acres.			*Acres.*	
United States	10,274,089	$25,462,250	Minnesota	250,805	$1,395,110
Alabama	569,160	121,225	Mississippi	222,800	78,505
Alaska			Missouri	783,646	294,865
Arizona	10,240	56,000	Montana	88,020	1,128,000
Arkansas	858,115	259,470	Nebraska		
California	356,815	440,750	Nevada	8,710	19,000
Colorado	113,820	935,500	New Hampshire	5,954	63,610
Connecticut			New Jersey	71,074	252,240
Dakota			New Mexico	64,034	142,075
Delaware	3,305	15,675	New York	149,491	1,210,785
District of Columbia			North Carolina	546,102	357,980
Florida	105,320	69,900	Ohio	74,114	797,170
Georgia	705,351	167,620	Oregon	132,320	593,850
Idaho	21,000	202,000	Pennsylvania	685,738	3,043,723
Illinois	48,691	45,775	Rhode Island		
Indiana	90,427	130,335	South Carolina	431,730	291,225
Indian Territory	1,000		Tennessee	985,430	5,254,980
Iowa	11,017	45,470	Texas	599,359	273,990
Kansas	7,080	14,700	Utah	42,865	1,042,800
Kentucky	556,647	237,635	Vermont	3,941	48,466
Louisiana	64,410	6,800	Virginia	272,319	326,944
Maine	35,230	123,315	Washington	37,910	713,200
Maryland	41,076	37,425	West Virginia	476,775	155,280
Massachusetts	13,899	102,262	Wisconsin	406,298	725,610
Michigan	238,271	985,985	Wyoming	83,780	3,255,000

From year to year there is, of course, great variation both as to area burned over and damage done by forest fires. Until within the last four years, however, very little really effective work was done toward checking or fighting forest fires. The best estimates indicate that the acreage burned over in the census year (1880) is a fair average for the period immediately succeeding it. As the area of commercial forest became reduced through lumbering operations and some protection was afforded timber in the West by the creation of forest reserves, the average area of mature forest burned over annually became gradually less. This reduction in area has, however, been much more than offset by the fact that since 1880 stumpage values have increased more than fivefold. It is safe to say that from 1880 to the present time the direct annual loss occasioned by the destruction of commercial timber by forest fires has been from $25,000,000 to $100,000,000, and in some cases greatly exceeding even the latter figure. The average loss from this source alone has been not less than $50,000,000.

In a few of the States of the East and Middle West the question of protection from damage by forest fires has been agitated for a long time. As a result, forest commissions have in some cases been appointed and steps taken to determine the amount of damage done, in order that the public might be fully awakened to the necessity for taking definite action to lessen or prevent further damage from this cause. The following statistics as to areas burned over and the value of property destroyed are taken from these official reports:

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Area burned over and amount of damage done by forest fires in Maine.

[From state forest reports.]

Year.	Area burned.	Damage.
	Acres.	
1903	269,451	$95,243
1904	6,958	12,655
1905	20,316	63,623
1906	7,528	20,919
1907	4,633	11,050

Annual loss in Massachusetts from forest fires.

[From State Forester's Bulletin No. 5.]

Year.	Area burned.	Damage.
	Acres.	
1885	.....	$82,254
1895	.....	107,150
1899	6,906	58,073
1900	51,807	140,456
1901	6,125	20,559
1902	51,578	26,526
1903	11,587	35,513
1904	1,339	14,764
Average	21,557	60,662

Figures for 1905, 1906, and 1907 not obtainable.

Acreage burned over and damage done by forest fires in Minnesota.

[From annual reports of chief fire warden of Minnesota.]

Year.	Area burned over.	Damage.	Year.	Area burned over.	Damage.
	Acres.			*Acres.*	
1895	8,265	$3,125	1902	18,285	$3,820
1896	14,912	16,059	1903	15,585	28,292
1897	66,020	22,455	1904	21,920	21,670
1898	21,580	9,063	1905	102,968	58,680
1899	3,635	1,541	1906	11,561	15,115
1900	179,521	153,399	1907	10,385	16,145
1901	6,120	2,404			

Acreage burned over and damage done by forest fires in New Jersey during the years 1872–1907.

[From report of forest park reservation, 1907.]

Year.	Number of fires.	Acres burned.	Acres per fire.	Estimated damage.	Damage per fire.
1872	.....	100,000	.....	$1,000,000	.....
1880	54	71,074	1,316	252,240	$4,671
1885	.....	128,000	.....	1,128,000	.....
1895	49	66,120	1,349	600,000	12,245
1902	65	98,850	1,520	169,323	2,605
1903	79	85,046	1,076	305,744	3,870
1904	81	41,530	512	193,413	2,388
1907	167	11,525	69	11,647	70

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Fire damages in Adirondack and Catskill regions, New York.

[Compiled from state reports.]

Year.	Area burned over.	Estimated damage.
	Acres.	
1891	20,477	$36,626
1892	5,903	7,350
1893	10,137	11,825
1894	22,962	56,716
1895	2,448	4,309
1896	29,817	35,640
1897	26,187	26,941
1898	9,118	7,030
1899	79,653	86,893
1900	14,893	16,414
1901	7,780	3,960
1902	47,936	31,790
1903	500,518	483,116
1904	2,627	1,500
1905	27,614	24,810
1906	4,203	8,335
1907	19,800	27,853

Acreage burned over and damage done by forest fires in Pennsylvania.

[From reports of Pennsylvania Department of Forestry.]

Year.	Area burned.	Damage.
	Acres.	
1900	266,027	$834,203
1901	73,005	238,374
1902	158,572	620,573
1903	64,186	241,240
1904	63,211	135,873
1905	18,642	63,915
1906	44,495	70,070
1907	19,389	73,623

Acreage burned over and damage done by forest fires in Wisconsin.

Year.	Area burned.	Damage.
	Acres.	
1904	56,777	$867.20
1905	76,125	1,529.60
1906	35,779	878.28
1907	54,278	1,995.26

It will be noted that the figures for the damage done since 1880 are almost universally less than those given in the census estimate, and in some cases the discrepancy is very great. It should, however, be borne in mind that the States have never taken such pains to secure a careful estimate as did the Census Bureau in 1880, and that the figures given in the state reports are for the most part based upon mere guesses, since in practically no case has money been available for adequate investigations as to the actual area burned over and an estimate by a timber cruiser of the damage done. In general, little or no account has been taken of fires in the more remote and unsettled regions. Neither has there been any pretense of estimating for the young or middle-aged growth, which in a few years would have had

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a distinct market value. The importance of this is greatly emphasized by the rapid rise in stumpage prices and by the fact that, owing to reckless methods of lumbering and the almost total lack of protection from fire, the area of virgin commercial forest remaining uninjured by fire has rapidly decreased. It must be admitted that while the estimates in the Tenth Census are unreliable, those contained in the state reports are for the most part much more so. As a matter of fact, it is practically certain that almost without exception the figures given represent but a fraction of the actual damage. The need for reliable statistics along this line can hardly be overestimated.

(3) DESTRUCTION OF THE YOUNG GROWTH.

This is by no means the least of the damage which results from forest fires. The perpetuation of the forest by wise use constitutes the distinguishing difference between forestry and old-time lumbering. The forest should be regarded not as a mine which is exhausted when the material is once removed, but as a reproducible resource, the quantity and quality of which may by protection and management be made better than the product of nature alone and unaided. The perpetuation of the forest, however, implies the protection of the reproduction, since it is only by the development of the young trees that the mature forest is produced.

A fire in destroying mature timber kills at the same time the young trees which, had they remained, would have constituted the future forest. The damage done by surface or grass fires is not, however, generally realized. The general effect of surface fires upon young growth is well illustrated by the results of the annually occurring grass fires upon the reproduction of longleaf pine in the Southern States. Seedlings of this species if not killed outright, are injured by the killing or burning of the buds, leaves, and bark, and by the heat which injures the cambium and roots. The extent to which seedlings are injured depends primarily on their size. Certain it is that all seedlings up to an age of one year are consumed by even a light grass fire; the second year perhaps an occasional one escapes, but during the first two or three years practically all are killed, if not consumed. After this age each annual fire works more or less injury until a diameter of 2 to 4 inches is reached. A mere grass fire does not seriously injure seedlings three-eighths of an inch and more in diameter. The leaves burn off to within 1 inch of their base, but if the bud is uninjured the trees continue their growth. The bracts around the bud are very inflammable and where burned death results, but the buds are well protected by the whorl of leaves below, and hence are seldom killed. When the leader is killed, a side shoot usually takes its place. The side shoots by their horizontal or oblique position suffer more than an upright stem.

Although grass fires destroy nothing of present commercial value, they do destroy property of which the prospective or expectant value is very great. The truth of this principle will be more easily recognized with regard to forest plantations than where the young growth is the product of the unaided forces of nature. Where time and money are expended in preparing land and in planting young trees, the reasonableness of a claim for reimbursement will be readily

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admitted in case the plantation is maliciously or carelessly destroyed. In Europe this principle is fully recognized, and actions for damages are based upon the so-called "expectancy value" of the stand. This amount is determined by discounting for present value the amount which the stand would have been worth had it lived to maturity, making due allowance for rate of interest, time of harvest, probable amount and value of product, and other factors. Forest growth is a crop of the soil, precisely like agricultural crops, the only difference being in the manner of originating, caring for, and determining the maturity or time of harvest. This being admitted for forest plantations, it must also be admitted for areas on which reproduction is natural as distinguished from artificial, but upon the care and protection of which the owner has expended time and money with the intention of harvesting the crop when mature.

The loss due to destruction by fire of young growth upon wild forest land of mixed-age classes is no less real, since had only the mature timber been removed or destroyed the remaining young growth would have produced a commercial forest of easily ascertainable value within a definite period of time.

As emphasizing the point of view taken abroad with regard to the expectancy value of young forest growth, the attitude with regard to the insurance of forest property is of interest.

In many European countries the supply of virgin timber has long been practically exhausted, and the people are dependent upon what can be grown commercially, aided by imports from less settled regions. Stumpage values are high, and the revenue-producing value of forest land is fully realized. Under these conditions, planting is in many cases resorted to rather than natural reproduction. This involves a large initial outlay and a continual expense for necessary care. Profits are certain if the crop reaches maturity, but there is always the possibility of loss from fire or other natural agency. As a result, there has been developed a well-defined system of insurance of forest properties. With stability in business conditions, rates of insurance are reasonable, and the growing of forest crops is thus put on a sound basis and is subject to no greater risks than any other legitimate business.

In the United States the insurance of forest properties from damage by fire has been taken up in only a small way. A beginning has, however, been made and at least one company is now engaged in this class of business. With an increase in the number and size of planting operations for commercial purposes, the necessity for this form of insurance will be more fully realized and it will become as common as it is now in some parts of Europe.

It has been customary in the past for Americans to consider forest land of value only for its actual stand of merchantable timber. Of late years, however, the value of absolute forest land is coming to be recognized on account of its ability to create value through the production of wood crops, just as farming land is valued because of its ability to produce agricultural crops. Ownership in the land should be regarded as an investment and the wood crop as interest. Where the reproduction is destroyed, it may be anywhere from a few years to several centuries before a natural regeneration can take place and the land be again restocked. In the meantime the land is practically idle and the investment is producing no return to the

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owner. This is as true where the owner is the federal or a state government as it is where the land is owned by a corporation or individual.

The loss of time involved in the natural restocking of a burned-over area varies greatly according to the size of the burn, the number, kind, and location of seed trees, and soil and climatic conditions. Very large clearings or burns can not be restocked from trees now standing on the border. It is usually a question of the progression of the forest on the clearing by successive generations of trees. The seed trees now standing distribute seed as far as the wind will carry it, and reproduction occurs in greater or less amount within that range. Near the seed trees the stand may be good; farther away the forest is more open, and on the edge there are merely outposts representing the seed borne to unusual distances by exceptional winds. As soon as these trees are large enough to bear seed, reproduction will occur in the openings about them, and there will be a further advance of the forest. This will continue until the entire area has been restocked. This process is exceedingly slow, compared with the results obtained by planting or by natural regeneration where young growth has been preserved and protected.

How much the loss by the destruction of young forest growth amounts to each year is difficult to conceive, even approximately. There are about 600,000,000 acres of woodland in the United States. It may be assumed that 200,000,000 acres of this area are in forest still uncut and not burned, leaving 400,000,000 acres of cut-over and burned-over land. This land varies greatly in productiveness, but it is safe to estimate that on the average it is capable of producing an annual growth of 20 cubic feet per acre. Protection from fire alone would have secured this result had preventive measures been taken from the beginning. Proper management would greatly increase it. Over very large areas, natural reproduction can not now be depended upon, owing to unfavorable soil conditions and the absence of seed trees. Thus a great expense for artificial reforestation will become necessary to repair the damage caused by long neglect. The producing capacity of the 400,000,000 acres with fire protection alone would thus be 8,000,000,000 cubic feet, equivalent to 40,000,000,000 feet b. m. per year. On account of the destruction of seed trees and of young growth by forest fires, it is estimated that not to exceed one-fifth of this amount is actually being produced on this area. This leaves a net loss to the country of 32,000,000,000 board feet per annum. At $2 per thousand stumpage this represents an annual loss to the country of $64,000,000. The annual loss thus directly due to the failure of the country to adopt measures for the prevention and control of forest fires is equivalent to 80 per cent of the total lumber cut of the United States, or to 32 per cent of the total consumption of wood materials of all kinds.

There is another point of view from which this loss may be estimated. It may be conservatively stated that 5,000,000 acres of land are burned over each year on which there is a stand of young growth which, if protected, would become a valuable stand of commercial timber. It costs on an average not less than $10 per acre to plant cut-over or burned-over lands. At this rate the annual loss to the country from the destruction of young growth alone is not less than $50,000,000. As a matter of fact, the actual direct loss from this

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source is much greater. The above figure makes no allowance for the fact that if the area is replanted, the forest will be but 3 or 4 years old, while that destroyed will usually average considerably older, varying from 1 to perhaps 50 years. The loss of interest on the investment represented by the value of the land during the time thus lost is an important consideration.

(4) EFFECT ON DISTRIBUTION AND COMPOSITION OF THE FOREST.

Forest fires affect not only the composition or make-up of the forest, but its distribution as well. Where repeated fires result in the total destruction of the forest cover, its replacement through natural means depends upon many conditions, and may not take place for hundreds or thousands of years, if at all. In general, the replacement of the forest on large areas of burned-over lands in the Rocky Mountain region is exceedingly slow, while in the coast region and in the eastern States it is much more rapid.

The change in the composition of the forest depends entirely upon the intensity of the fire. When great damage is inflicted upon the soil, its ability to produce spontaneously a crop of trees similar to the one destroyed is lost, and the subsequent forest is only produced if at all, through the restoration of fertility, following the slow growth and decay of many generations of less valuable plants. On the other hand, where the fire is light, burning merely slash resulting from old cuttings, and destroying the reproduction without doing any material injury to the soil, it is not many years before a new vegetation establishes itself and no real change is brought about in the composition of the forest.

The time required to seed a burned area with the valuable species destroyed depends entirely upon the severity and extent of the fire. The light-winged seeds of the conifers travel great distances, but a complete seeding of the ground can not be depended upon for a greater distance than one-quarter of a mile from the parent tree. Assuming that a conifer must be at least 30 years old before it can produce fertile seed, it would take at least thirty years to seed a burn over half a mile in diameter, at least sixty years to seed a burn 1 mile in diameter, etc.

The spruce forest of the Northeast consists chiefly of an uneven stand of spruce, balsam, birch, maple, yellow birch, white pine, etc. When burned over the ground becomes occupied by a temporary type of light-demanding species, such as fireweed, bird cherry, popple, soft maple, and birch. The last three species are good sprouters and grow from roots already well established. The popple often grows from underground stems or suckers, thus adding materially to the rapidity with which it comes in upon burned areas. As these light-demanding trees grow in height the confers, being quite tolerant, come in under the shade afforded by the former and establish themselves in the stand. Birch, popple, bird cherry, and soft maple grow very rapidly at first, but they are not at all persistent in their height growth, and are soon overtopped and killed by the slower-growing but more persistent conifer. With the death and disappearance of the above-named hard woods, the forest resumes its coniferous character.

In the white-pine region of New England and Pennsylvania the prominent type is a mixture of white pine, red, white, and black oak,

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chestnut, maple, ash, etc., the hard woods tending to occupy the better soils. When a severe fire occurs, destroying the vegetable matter in the soil and killing young growth and seed trees, freer seeding and less exacting species like gray birch and pitch pine, and such shrubs as scrub oak and laurel, take possession. Eventually, however, the area will revert to its original type, as in the case of the spruce forest.

Where the fires are less severe, killing only the young growth and not injuring the soil, the effect is usually to favor the free-sprouting hard woods, which occur naturally on the better soils. As this is a prominent type it then becomes difficult for the more valuable white pines to recover the ground which they have lost.

In the upland longleaf pine region of the South, after an area has been culled by lumbermen so that only a thin stand remains and the ground is burned so closely as to prevent pine reproduction, there often occurs a thick stand of jack, scarlet, post, and upland willow oaks. There is thus formed a two-storied forest, with these oaks as the under story. The large pines in such a forest are present in varying numbers, from 30 to 40 per acre to 3 or 4, or occasionally entirely wanting over limited areas. The tendency of such a condition is to reduce the number and severity of the fires. The oaks by their shade reduce the density of the grass cover and the number of low shrubs so that often there is not sufficient fuel to support a fire. The bunches of wire grass are widely separated, and as the fallen oak leaves do not carry fire unless there is much head, a running fire soon loses headway unless fanned by a strong wind. Land of this character presents one of the most hopeless and deplorable features of fire injury. It is not safe to say that this worthless oak would not spring up upon the cutting of longleaf pine, but it would not cover the ground so exclusively were it not for the fires which kill the longleaf pine seedlings, which would compete against it for possession of the ground. With fire as an ally the oaks have all the advantage. Another advantage is the frequent oak mast as compared to the rare production of longleaf pine seeds. Even if both seed the ground and the seedlings share alike for the first year or two, the inevitable fire will kill the pines outright, whereas the oak will be killed to the ground only to sprout anew the following year or often the same season. The sprouts grow with marvelous rapidity and soon get above the fire danger and shade out the few pines that perhaps escaped the first fire. Once in possession of the ground, the oaks give no further opportunity for pines to establish themselves. Except for the damage to the soil there can be no harm resulting from fire in oak scrub land. If the oaks are injured so much the better. Prevention of the fires which give the oaks first possession is the thing to be sought for.

The effect of the fires upon the loblolly pine land of eastern Maryland and Virginia is illustrated by great stretches of waste land covered with a thick tangle of huckleberry, laurel, green brier, etc., with a scattering of loblolly and other pines. The loblolly is a free seeder and would take possession again were it not for the recurrent fires.

In a shortleaf pine region fire results in great damage to the forest. The reproduction of pine is largely prevented and an undesirable growth of inferior hardwood sprouts results, as described for the longleaf region.

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In the Rocky Mountain region the struggle of the trees is not so much against each other as against adverse climatic conditions. Of these the most important is the low annual precipitation. Fires in that region have resulted in the laying waste of vast areas. The fact that seed years of the native species may occur only at infrequent or irregular intervals intensifies the uncertainty of reforestation through natural means. This is especially true of Engelmann spruce in the Rockies. Unless favorable climatic conditions and a good seed year happen to occur at the same time the seeds fail to sprout or the seedlings fail to live and the establishment of a new stand is delayed indefinitely. Seed, moreover, is not always plentifully produced, because in this high altitude and peculiar location the meteorological conditions are anything but favorable to regular, abundant seed production, and when seed is produced a large portion of it becomes food for birds and other animals. Of a large area in the southern portion of the Pike National Forest, Colorado, burned over about 1850, less than 10 per cent is estimated to have become restocked through natural means.

Two trees, however, are well adapted to cope with fire, the aspen and the lodgepole pine. The former certainly and the latter in many cases may be regarded as temporary types preparing the way for more valuable species like Douglas fir, yellow pine, and Engelmann spruce.

The relation of lodgepole pine reproduction to fire is an especially interesting one. In the first place, the cones often do not open, but remain on the trees for many years; and in the second place it demands a mineral soil in order to germinate well. Since fire provides a mineral soil and opens the cones, the lodgepole pine is favored by it, and the tremendous areas of logpole forests in the Rockies are largely the result of fire. This is not always true, however, for if the fire should come before the stand has reached seed-bearing age complete destruction will result. The reversion of timber land to chaparral, through repeated fires which kill the reproduction and eventually the seed trees, is one of the serious problems in the commercial forests. The chaparral is able to endure these repeated fires, since it sprouts from the root. It has in this way obtained possession of enormous areas once densely forested. One of the best examples in northern California is seen around the base of Mount Shasta.

The unwritten history of the Southwest is phenomenal. The prehistoric aborigines must have exerted a marked influence upon the vegetation of the country. Their fires, and those of the historic races, unquestionably account for the open condition of the forests. The high pine forests were their hunting grounds, and the vast areas of foothills and plateaus, covered with oak and nut-bearing pines, their harvest fields. Here they lived in their summer homes, kindled their camp fires, and harvested crops of acorns, nutritious nuts, and in many instances cultivated vegetables and cereals.

Possibly no forests on the Pacific coast show so small a percentage of regrowth and so slight a tendency to reproduction as do the forests of the Mogollon Mountains, which extend through New Mexico and Arizona. This is due not entirely to the arid condition, as is popularly supposed, but to the continued occupancy of the country for centuries by prehistoric races, who merged into the Indian tribes occupying the country at the present time. All through Arizona

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the regrowth of pine forests dates somewhere during the past half century, and with a few exceptions nowhere antedates the early settlement of the country by our own race.

From Puget Sound to the Gulf of California these people rambled at will, but their abiding place was on the border land between the forests proper and the "Staked Plains" in the Southwest. The extensive ruins indicate that they inhabited the fringe, so to speak, of the forests which, like vineyards, were working their way down from the mountain tops into the desert plains. The most potent and powerful weapon in the hands of these aborigines was a firebrand. It was alike used to capture the deer, the elk, and the antelope, and also to rout or vanquish the enemy. It cleared their mountain trail and destroyed the cover in which their quarry took refuge.

In the North nature was quick to heal the ravages of fire, and the damage of forest growth was reduced to the minimum. In the dry and more arid regions nature recuperated slowly, and the relentless flames left an indelible mark. In Chaco Canyon, where a deep arroyo or wash has cut the depth of 30 feet through a sedimentary formation, distinct strata of earth, impregnated with charcoal, from 15 to 20 feet from the surface, may be traced over an area of many thousands of acres. Elsewhere the alluvial and silt deposits and forest trees have recorded the unmistakable evidence of numerous and extensive forest fires which have occurred at intervals during many centuries.

How far the occupancy of the prehistoric and historic tribes has retarded the progress of foresting it is impossible to say, but it must have been no small factor. These areas—that is, those most frequented by the cliff, caveta, and pueblo builders—were then and are now of great importance, because in the region inhabited by them the battle between vegetation and the unfriendly elements was and is now fiercest. These areas form the boundary between the forest and the desert. Vegetation is here dwarfed, but struggling to enlarge its domain. Were it not for the long Indian occupancy and the ravages of fire incident to their habitancy, vast territories now barren wastes might be covered with a forest growth, at least such as is indigenous to arid regions. Irrigation would have reclaimed many hundreds of acres now hopelessly barren.

In Arizona there are no young forests of any considerable extent antedating a period of forty years and almost all of the regrowth has sprung up during the last quarter of a century. A single exception may be noted in the White Mountains, which have been occupied for a couple of centuries by the Apache Indian. These forests show in certain localities all classes of regrowth and are in marked contrast to the mountain country occupied by the Navajo Indians in the northeastern portion of the Territory. The Navajos have possessed sheep and goats and followed pastoral pursuits for over two centuries. The forests occupied by them show practically no regrowth. The Apaches have followed the chase and war and have entrammeled themselves with nothing but war ponies. The forests within their domain, where they have not seen fit to apply the torch in accord with their well-grounded supersitition that forest fires cause rain, show a regrowth gradating into many past decades.

Fire, with or without the aid of lumbering, is directly responsible for the chaparral upon the western slopes and foothill regions of the

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mountains of California. Of three and a half million acres examined in the mountains of Butte, Plumas, Sierra, Nevada, Yuba, and Placer counties, in southern and central California, approximately 213,730 acres are under chaparral cover. If an artificial grouping were made it would throw the chaparral into two types of classes: (1) That which has evidently been in possession for a long period of time, and (2) That which has taken possession since lumbering and fire removed or thinned the forest growth. In one case natural causes, mainly fire, are responsible; in the other largely the result of man through lumbering. In both cases the chaparral covers the sites of former forests, the main difference being the time and rapidity of the transition.

The first-mentioned type is found mainly at the higher elevation, seldom below 4,000 feet. These high, brush-covered ridges show external evidence of having been timbered, examination revealing the presence of old stubs and charred logs among the densest chaparral, often entirely covered with soil; while the soil conditions are as good as in the adjoining timber. Each succeeding fire reduces these evidences of former timber growth, kills a few more trees along the disputed boundary, and extends the line of chaparral farther back into the forest. The principal reason for the rapid advance of the chaparral at the expense of the forest on the higher elevations is that fewer species and less fire-resisting ones occupy these upper slopes. The fir, especially until the polewood stage is passed, is very susceptible to fire. It is, however, one of the first species to work back into the chaparral, and in many places would regain possession if it were not for recurring fires.

The chaparral of the lower slopes is practically the same as the other, save that it has appeared more recently, and is the direct result of lumbering followed by successive fires which killed the reproduction and the thinned stand of culled timber. The result of the change in composition of the forest from commercial timber to chaparral is that the capacity of the land to produce revenue in the shape of a valuable crop is lost for an indefinite period. An additional point is that the chaparral is less valuable as a protection to the watershed than a forest cover since the latter produces better conditions of soil and humus and is more effective in preventing evaporation. The presence of the chaparral cover, however, renders planting operations so difficult and so expensive that reforestation with commercial species is in most cases impracticable as a business measure.

In hardwood forests, in general, the effect of fire is to reduce the percentage of seedling trees, and to increase the number of sprouts. As sprouts rarely produce first-class timber, the result is deterioration of the forest. Fire also favors the freer-sprouting, faster-growing species like the chestnut and the black oaks, and the less exacting species. Frequent killing back, however, reduces the vitality of the stools and often kills them entirely so that large areas become covered with such shrubs as laurel, rhododendron, huckleberry, etc.

The effect of fire in the sprout forests, because of the density of the stand and moderate height of the trees together with the crookedness and irregular forms of growth, is even more destructive than in seedling forests of similar species. In young stands the destruction is

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often complete while the dead, half-burned stems that remain standing add to the danger of a second fire.

Many of the so-called prairies are capable of bearing forests and possibly were originally timbered. This is not only true of the great prairie belts of the Middle States where the western line of forests has been pushed far to the east through the agency of fire, but is also true of the prairies found within forest regions, such as those occurring in southern Minnesota, Illinois, Tennessee, etc. In many of the interior prairies forest conditions are already becoming rapidly established since the prevalence of fires has been decreased.

(5) DETERIORATION OF THE SOIL.

It is impossible to estimate even approximately the loss caused by the deterioration of the soil due to forest fires. In mountainous regions there is no question that the loss from this source is frequently greater than from the destruction of the original stand of timber. The building up of the soil in mountain regions is a matter of evolution, resulting from the decomposition of rock in place and of the vegetable matter formed by many generations of lower plants, or by the washing down of these constituents from higher slopes. On many slopes the presence of any forest growth whatever is due to the accumulation through the ages of a mass of organic matter which held the mineral particles of rock as they were gradually disintegrated, preventing their being washed to the bottom of the slope. It may take hundreds or thousands of years for the soil on a slope to reach a sufficient depth to produce a stand of commercial timber. When the forest growth and other ground cover are destroyed by fire and the organic matter partially or totally burned, the bare, shallow, mineral soil is left to be blown away by violent winds and to be washed away by the rains. The capacity of the area thus denuded to produce a valuable crop is in this way delayed indefinitely, and at the same time immense damage may be done by the deposit of soil thus washed down upon valuable farm lands below. This has been notoriously the case in the Southern Appalachian Mountains.

Where the slopes are not sufficiently steep to facilitate the washing away of the soil, forest fires by destroying the humus may affect injuriously both the fertility and the physical condition of the soil. The loss in fertility is of the lesser importance since of the constituents necessary to tree growth, one-half, namely, carbon, is furnished by the air, and almost all of the other half is furnished by the water of the soil. In general the soil is increased in fertility by the presence of forest growth, while the opposite is true of agricultural crops. The damage to soil fertility on lands not suitable for agriculture may thus be overrated, so far as the mineral composition is concerned.

The fertility of the soil for the support of forest growth is, however, much more to be found in the physical condition than in its mineral composition. In the case of agricultural lands the physical conditions can be regulated by artificial means, as by plowing and cultivating. This, however, is impracticable to any extent with regard to forest lands. The surface cover has an important influence on the physical conditions of the soil, and its destruction by fire may be most detrimental. Changes in soil conditions primarily affect

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water supply and stream flow, and for that reason will be discussed under the next heading. For the purposes of this subdivision it need only be remembered that the amount of wood increment is in proportion to soil conditions, and that a deterioration of these is reflected in a reduced annual wood deposit as long as the unfavorable conditions last. There is thus a distinct loss due to the rate of growth having been damaged, and the amount of wood increment being correspondingly decreased as a result of forest fires.

(6) INJURY TO STREAM FLOW.

Investigations indicate that the presence or absence of forest cover has but little if any influence in increasing the rainfall and the annual run-off. There is no question, however, but that the forest does subserve an exceedingly important function in regulating the disposition of the precipitation after it reaches the ground. It shades the soil and breaks the force of the wind, thus lessening evaporation, both of soil moisture and of rainfall. The result is that a larger percentage of the precipitation passes into the streams, either directly as a part of the surface drainage, or indirectly through seepage, and thus becomes available for irrigation or other purposes. The effect of forest cover in retarding surface drainage is also well recognized. This is accomplished by the mechanical effect of the vegetation in retarding the flow of surface water and by its function as an absorbent, changing the rapid surface run-off, with its great possibilities for damage, to the slower process of seepage drainage, whereby the volume of stream flow is equalized and its occurrence distributed through longer periods of time.

Where the forest fires result in the partial or total destruction of the forest cover the nice balance of nature is destroyed and the above conditions are reversed. The result is that snows melt more rapidly in the spring of the year, the soil washes away, or its physical condition is so changed that its capacity to absorb and retain precipitation is damaged, and an alternation of floods and droughts occurs, in place of the former comparatively steady stream flow. The value of streams for irrigation, power, and navigation is greatly lessened on this account, since the volume may be greatly decreased, or the flow cease entirely during the dry season, when it is most needed. Greatly increased facilities for the storage of water become necessary in case the water is to be used for irrigation. This added expense is further increased by the additional damage done by the silting up of reservoirs at times of flood water.

Concrete examples are not wanting, which demonstrate the results bound to follow if present lumbering methods are not modified and protection from fire secured.

A point not often considered is the effect of forest fires in increasing the number and severity of snowslides and landslides. It is a well-known fact that in Europe not only torrents, but landslides and snowslides are induced and aggravated by the removal of the forest cover, and also that the formation of these slides has been prevented by reforesting the denuded mountain slopes. Timber at high altitudes affords the best protection against snowslides. The importance of the forest in this respect was recognized in the Alps centuries ago, and wherever "ban" forests were maintained, immunity from

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avalanches to the extent of the forest has been secured. An interesting account is given of the ban forest of Urseren, which was reserved by the community as early as 1397, and of the constant fight which was necessary against reckless advisers to keep it intact, until now the beneficial effect is fully recognized and reforestations have been begun under the protecting walls or other safety works wherever the danger of avalanches exists.

Yet even timber forest is not absolute protection against avalanches, since the place of incipient formation of the slide may lie above timber line. There is no question, however, that the interlacing of the roots of trees has a decided tendency to prevent movements of the soil, and the mechanical obstruction furnished by the trees themselves is an important factor in preventing the inception of snow and land slides and in checking them when once formed. Conversely, the destruction of the forest cover at high elevations through the agency of fire, while not necessarily an original cause, undoubtedly contributes to the evil effect.

Snowslides are frequent in the Rocky Mountain region, more especially among the higher Colorado ranges. Hardly a year passes without the report of serious loss of life and property from this source from the regions near Silverton, Ouray, Aspen, and Leadville. In a number of instances entire mining camps have been engulfed. Landslides are of less frequent occurrence, but they do nevertheless occur, and are of increasingly frequent occurrence with the settlement of the country and the consequent denudation of forest lands on the steeper slopes.

In addition to the loss of life and property, the occurrence of snowslides has a bearing upon streamflow. The mechanical effect of both snow and land slides in removing the soil covering from steep, rocky slopes and in preparing the way for further washing and gullying is well known. But little attention has, however, been paid to the effect of snowslides upon the distribution of streamflow throughout the year. The snow which falls at high elevations naturally melts less rapidly than that which is deposited upon the lower slopes. A snowslide results in the transfer of an immense volume of snow from a higher to a lower altitude. Under the new conditions the snow in general melts more rapidly than would have been the case had it remained on the higher slopes. In addition, it must escape chiefly as surface run-off, instead of soaking gradually into the soil at the higher elevations and seeping out below all through the year as a feeder to the springs and smaller streams. The result is that instead of a moderate flow extending all through the year there is a flood in the early spring, resulting in excessive erosion of agricultural lands above, the silting up of dams and reservoirs, and the destruction of or great injury to valley lands below by the deposition of vast quantities of soil and gravel washed down from the hills. Then, following the flood, occurs a period of excessively low water or absolute drought, making impossible the utilization of the natural capacity of the soil for storage purposes, and rendering it necessary, in order to utilize the stream for irrigation, to incur great expense in the construction of storage dams and reservoirs, the maintenance of which is in turn made more costly on account of the tendency of the stream to carry an excessive amount of silt during its high stages.

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(7) INJURY TO GENERAL BUSINESS INTERESTS.

The vital relationship existing between the lumbering industry and the great industries of transportation, agriculture, mining, and manufacture is unquestionable. The forest furnishes raw material which is indispensable in all, and in addition furnishes a not inconsiderate portion of the traffic upon which the prosperity of the railroads depends. Forest fires, by destroying vast quantities of standing timber and making the natural restoration of the forest impossible over large areas, have seriously lessened the available present and future supply of timber and thus brought about a general increase in the cost of raw material. This has in many cases resulted in decreasing profits, though as a general rule the increased cost of raw material has brought about a corresponding increase in the price of the finished product, the loss thus being transmitted to the general public. Forest fires, however, brought about the direct destruction of a vast amount of private property in the form of buildings and manufacturing plants of all kinds. By destroying in many cases the only available source of raw material, they have made necessary the closing down of business enterprises, thus rendering the money invested in manufacturing plants a partial or total loss. This is particularly true of lumbering operations and sawmills. It is true also to a certain extent of pulp mills, since an expensive plant is of less value where it can be supplied for only a limited period of time than if the supply were sufficient to permit operation for an indefinite period. Fires, by destroying young growth, cut off the future supply and make necessary the earlier removal of plants than would be the case were the forest protected and made to yield a continuous crop.

Nor is even this all. Over large areas the forest is killed and the material made worthless, but the accumulation of millions of cords of this material still remain on the ground, which soon decays and loses its sale value. It takes many years, however, before decay becomes complete. It is material of this kind which furnishes fuel for the terrible fires which occasionally sweep over vast areas. In Michigan the forest fires of 1871 killed great quantities of timber; the fires of 1881 devoured the stuff thus killed a decade before, and were rendered unusually severe because of the vast quantities of débris. For years the areas run over in 1896 will be in danger of renewed and more severe fires. The constant menace of fire is a thing to be avoided, since it imperils not only all the property in its way, but human life itself. The clearing of these burned-over wastes is a severe task, and the settler is not able to partially reimburse himself for his work by the sale of logs, as would be the case were the timber uninjured. As a result of these conditions, settlement in burned-over areas progresses very slowly, even where the land is fairly well suited for agriculture, as it is in most parts of the Middle West. It is stated by the forest warden of Michigan that forest fires have done more to hinder settlement in the northern counties of that State than all other agencies combined.

An additional point not generally considered in connection with the destruction of timber is the fact that the community as a whole is injuriously affected, since its power for development through taxation is decreased. Under our present system of taxation, unimproved, burned-over land must necessarily be assessed at a much lower rate,

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for purposes of taxation, than when it contained a stand of merchantable timber. This is especially true where the land is not chiefly valuable for agriculture but serves its best purpose as a producer of wood crops. Where settlements exist, an increased burden of taxation is cast upon other forms of property for the maintenance of roads and schools and other incidents to local government. In other words, in order to raise a fixed sum of money the tax rate must be raised in order to compensate for the decrease in the amount of taxable property. This in turn is reflected in a general lowering in the values of all forms of property thus taxed. Where settlements do not exist, development is greatly retarded, since the lack of taxable property renders the construction and maintenance of roads and schools a difficult matter. In fact, in many parts of the country, the combined effects of lumbering and fires has been to bring about the reversion to the State of vast areas of land for nonpayment of taxes. A notable instance in this regard is the State of Michigan. There were in that State, in 1907, 9,000,000 acres of state-tax lands, of which not less than 7,000,000 acres were, according to Professor Roth, cut-over lands, mostly pinery, burned and reburned, with the exception of the swamps. The reversion of these lands to the State withdrew them from taxation entirely, and as a result the development of the counties in which they were located has been exceedingly limited and slow. Had it not been for fires it would, in many cases, have been good business policy for the owners of the land to retain it in order to allow the young and middle-aged growth to attain maturity and be harvested. These lands would in the meantime have been subject to taxation and would thus have aided in the settlement and development of such portions of the region as were chiefly valuable for agriculture. The reforesting of such lands by the State and the payment to the county of a portion of the revenue, in lieu of taxes, offers the best solution of the problem, under present conditions.

Many of the mountain regions of the United States derive a large revenue from summer visitors. For instance, the White Mountains, in New England, and the Adirondacks, in New York, are visited annually by thousands of people from every State in the Union as well as from foreign countries. These regions form vast recreation grounds for thousands of people. Their very existence as summer resorts depends to a large extent upon the beauty of the landscape and the clearness of the atmosphere. The natural beauty of the mountains is enhanced by their forest covering, and when this is destroyed by fire the landscape is rendered bleak and unattractive, thereby lessening the volume of travel. The result is directly translatable into a decreased revenue for the region so affected. What is true in this regard in the White Mountains and Adirondacks is true to an equal or greater extent in many other summer-resort regions throughout the United States.

The relation of forest fires to the naval-stores industry of the South has until recently received little or no attention. Turpentining has been followed by lumbering, so that the disappearance of the virgin forest has progressed steadily. This process has been accelerated by the weakening of the trees due to the burning out of the boxes by grass fires, so that the trees are easily blown down and immediate lumbering becomes necessary. Restocking and natural replacement

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of the forest have been made impossible over immense areas by the annually recurring grass fires, which destroy the seedlings before they can reach sufficient size to withstand the flames. The condition above described is to a very considerable extent responsible for the fact that the naval-stores industry in the South has never yet been placed upon a permanent basis. The depletion of the forest has occurred in one State after another, beginning with North Carolina and working steadily southward and westward.

The industry has unquestionably been conducted, for the most part, with the intention of obtaining the greatest return for the immediate outlay, irrespective of the waste and wanton destruction of the forests. The fear of exhausting the raw material of the live trees has led to the adoption in some localities of the Herty cup and gutter system. While this system undoubtedly brings about the protection of standing timber and an increase in the quality and quantity of the product, it does not bring about the perpetuation of the forest as such. There is no reason why the lumber and naval-stores industries should not be perpetuated together. Protection from fire in the southern forests would alone bring about the accomplishment of both these objects to a very considerable extent.

More importance is being attached to the second-growth pine than formerly. It is only in recent years that the owners of timber in the Southern States have had an opportunity of noting the value of this second growth and of forming some idea of the possibilities of this character of timber for the development of naval stores. The second growth, following the abandonment of old fields and the cutting away of permanent growth, has developed to the extent of service for turpentining purposes. It is the consensus of opinion among the operators to-day that if fires can be prevented the turpentine industry will be perpetuated, while a few years ago the prevailing opinion was that the turpentine industry would soon be a thing of the past in Florida. It is only recently that naval-stores operators considered it practicable to depend solely upon a second growth for turpentining. Now, however, it is reported that many of them believe that in the years to come there will be turpentine made from second growth alone and that the industry will be as successful then as now. If forest fires can be kept out, there is no question but that this is entirely practicable.

B. CAUSES OF FOREST FIRES.

The fire reports of forest supervisors, while applying only to the national forests, may be taken as a fair indication of the relative importance of the various causes of forest fires throughout the Western States, including the Rocky Mountain and coast regions and the Southwest. Of a total of 2,503 fires occurring in the national forests during the calendar years 1906 and 1907, 641 were reported as having been caused by railroad locomotives, 638 by campers, 458 by lightning, 49 by clearing and brush burning, 43 incendiary, 22 by hunters, and 652 from miscellaneous causes. These figures, while not complete, are sufficient to demonstrate the fact that the principal causes of forest fires in the Western States are railroad locomotives, campers, and lightning. Loss from the first two can be largely overcome by proper precautionary measures. The starting of forest fires

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by lightning can not be prevented, but it is entirely practicable to greatly reduce the loss by the adoption of some definite plan for extinguishing fires in their early stages.

To be classed with fires caused by railroad locomotives are those caused by donkey engines and sawmills. The loss from these sources, while comparatively small, is great in the aggregate. Since lumbering by donkey engines takes place only on the Pacific slope, the region subject to fires from this cause is limited in extent. Fires from sawmills occur at irregular intervals throughout the entire country wherever the mills are located in the midst of the lumbering operations. That the amount of loss from both these causes as well as from railroad locomotives can be very greatly decreased by precautionary measures has been amply proven by experience. The two most effective means to this end are the use of spark arresters and of oil burners. This has been demonstrated by the experience of the Forest Service in the protection and administration of the national forests.

During the year 1907, 273 fires were started upon the National Forests as a result of sparks from locomotives. There were during that year 32 Forests affected by railroad companies which burn coal and wood as fuel in their locomotives, many of which do not provide their locomotives with spark arresters. The reports upon these fires show that 75 per cent of the fires were started from locomotives not provided with spark arresters. During this same year 65 fires resulted from donkey engines used upon lumbering areas. It is required, however, that these engines be provided with spark arresters, since in all permits allowing the use of steam power a clause is inserted in the final agreement to this effect. It has been difficult to secure the general adoption of spark arresters, since all or nearly all the styles now in use interfere to some extent with the completeness of the draft. Especially on mountain roads does the ordinary type of spark arrester interfere with the steaming power. In many cases engineers have either removed the arresters or screens or else broken them, in order to increase the steaming power, so that the efficiency of the device as a preventive of fires along the right of way was entirely destroyed. The remedy lies in the selection of the best types of spark arresters and in the enforcement of the laws already existing requiring their use. It is, of course, essential that some system of inspection be provided by which it will be guaranteed that the screens will be kept in proper condition. Many types of spark arresters are in use, based upon different theories, and using different sizes of mesh in the screen. The standard spark arrester used by the Pennsylvania Railroad Company has a mesh of two and a half openings to the linear inch, using wire to No. 10 gauge (0.11 inch in diameter), reducing the size of the opening to 0.0841 of 1 square inch. It is believed by the officials of this company that instead of a device for catching the sparks and retaining them long enough to become cold, it is better to break them up into small sizes and throw them as high as possible. This gives them time to cool below ignition point before landing. Observation shows that in general sparks from an engine equipped with a spark arrester will fall inside of 20 feet from the track, while one not so equipped will throw sparks a distance of 50 feet, and on a very heavy up grade to as great a distance as 75 feet.

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The importance of keeping the right of way cleared of inflammable material is apparent.

Donkey engines are generally fired with refuse wood and limbs resulting from lumbering operations. This fuel contains more or less pitch, and this, acted upon by smoke and steam, forms a coating over the ordinary old-style screen, very seriously interfering with the draft. When this occurs the engineer usually either removes the screen or, in endeavoring to clean it with a rod or pole, so injures it that it is entirely useless for the purpose for which it was designed. Several improved styles have been designed to meet these difficulties, and the results are most encouraging.

The advantage of using oil as fuel in locomotives in preference to coal or wood, in decreasing the danger from fires, has been clearly shown by the results obtained upon the national forests. There are 912 miles of railroad within the national forests representing 38 different railroad companies. Of these, 25 companies use coal and wood in their locomotives and 6 use oil as fuel. From the 6 railroads burning oil, representing a distance of 82 miles, not a single fire was reported, while 273 fires were started by locomotives using coal or wood. That portion of the Southern Pacific Railroad traversing northern California may be cited as an example. On this portion of the line the coal-burning engines were converted into oil burning, and oil is now used exclusively as fuel. As a result the fire danger is reduced to a minimum, timber fires having been entirely eliminated, and there being no recurrence of the former difficulty with regard to fires in the snowsheds across the summit of the Sierra Nevada.

It is the policy of the Forest Service in connection with timber sales where railroad transportation is required, wherever such stipulation is considered reasonable, to insert in the final contract a regulation requiring the use of oil as fuel for the locomotives during the dry season of the year.

The substitution of electricity for coal as a motive power on railroads also offers great promise for the future safety of the adjacent forest from fire. It is announced that on that portion of the Chicago, Milwaukee and St. Paul Railroad which will traverse mountainous or timbered regions from the Rocky Mountains to the coast, electricity will be the motive power rather than coal. It is reported also that the same action will be taken by the new Western Pacific Railroad in crossing the Sierras in California, and that the Great Northern Railroad is planning to substitute electricity for steam in crossing the Rockies and the Cascades. Local water power will generate the electricity in each case.

Experiments carried on by the New York Central Railroad Company have demonstrated the entire practicability of this course. The extreme cost of transporting coal long distances in mountain regions, as contrasted with the convenient accessibility of water power as a source of electricity in these same regions, will gradually bring about a more general adoption of the example set by the Chicago, Milwaukee and St. Paul Company.

The second great cause of forest fires throughout the West has been the carelessness of campers and of others traveling through the forest. Thoughtlessness, ignorance, and disregard of any but personal welfare have been largely responsible for this condition. Camp fires left unextinguished and lighted cigars thrown away have caused

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many fires. Many set intentionally have been allowed to spread over large areas. Formerly it was a common practice in many parts of the West for sheepmen to burn over the ranges to open up the way for their herds and to get fresh grass and tender sprouts in the spring. These fires have frequently spread into standing timber and caused incalculable loss. In some cases prospectors have set the brush on fire to make traveling easier and to expose the rocks, thus facilitating the work on which they were engaged. The setting of fires to improve the range or to facilitate prospecting has been practically eliminated so far as the national forests are concerned. Carelessness and ignorance are not so easily reached, but much has been accomplished through education, patrol, and the enforcement of penalties in accordance with law. It is a fact that the worst fires have followed the advent of the whites, notwithstanding the fact that the Indians systematically fired many portions of the country to keep the woods open, and the early Spanish herdsmen in California burned the brush to facilitate travel and open up the country. Fires are also caused by lightning, toward the extinguishment of which in the early days absolutely no steps were taken.

The causes of forest fires named above for the western States are responsible in varying degrees for fires throughout the East South, and Middle West.

In the East and Middle West, while immense damage has been done by fires starting from locomotives, the principal source of danger has for a long time been the clearing of land for cultivation. The periods of greatest danger are in the months of April and May before the leaves have unfolded on the trees, and in September and October after the leaves have fallen. Numerous fires are also caused by the carelessness of hunters, campers, and fishermen. A strict enforcement of existing laws has already materially reduced the loss from these sources, as it has from the clearing of land for agricultural purposes. In many of the States a closed season has been established during which the burning of brush or fallows is made unlawful, or is allowed only under permit issued by firewardens, whose appointment is provided for by law. As a result there has been a very noticeable decrease in the number and severity of fallow fires. In some of the States the improvement has been so great that the damage from this source is very materially less than from fires set by locomotives.

The burning over of so-called blueberry or huckleberry barrens has been another fruitful source of fire damage in many of the Northern and Eastern States. In New England, New York, New Jersey, Michigan, and the mountain districts of Pennsylvania and West Virginia, there are many thousands of acres, worthless for agricultural purposes, upon which, after the removal of the timber and the burning over of the slash, there has sprung up an abundant growth of blueberry bushes, alders, poplars, birches, spiræa, and sweet fern. These lands have in general been considered as public property and recklessly burned over by irresponsible parties to promote the growth of blueberries and to destroy the birches and other plants which would soon shade the ground. The result has been that the fires have year after year encroached more and more on the forested areas, in this way destroying large quantities of valuable timber. Where the burn-

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ing is done too late in the spring the roots of the bushes are severely injured and a period of ten to fifteen years is required before they regain their producing capacity. In some parts of the country, however, particularly in Maine, the management of blueberry lands has been systematized, and the picking and canning of blueberries has become an industrial operation. Good blueberry land, properly managed, yields a handsome revenue. Economically considered, therefore, the blueberry barrens are in many cases justified. Unregulated burning, however, results in the loss of large quantities of valuable timber, the deterioration of the barrens themselves, and the retention in many cases as comparatively unproductive barrens of lands that would otherwise be producing a valuable crop of commercial timber.

Throughout the Southern States it has been the practice for generations to burn over the woods every year or two. Practically the whole forest burns over annually, usually between December 15 and April 15. Except in the swamps a piece of forest land that has remained unburned five years or more is rare. Practically all the fires are set intentionally.

The principal objects sought to be gained by these fires are: (*a*) To protect turpentine orchards by burning all combustible material at the time of the year when it will cause least injury to the naval-stores industry. Fires are ordinarily regarded as inevitable, and light annual burnings are considered as causing less damage to the mature timber than heavy fires at less frequent intervals; (*b*) to improve the range; (*c*) to protect fences and crops by burning the combustible material on surrounding areas; (*d*) to keep down reproduction and undergrowth and render the woods easy of access at all times.

The fire question is of paramount importance in the Southern States on account of its vital relation to the three forest industries of lumbering, turpentining, and stock grazing. It has been shown by experience that cattle exist quite as well on an unburned range. In fact, many of the more intelligent stockmen have for some time opposed all burning. That these annually recurring fires are resulting not only in the destruction of the present forest but in the prevention of a future one over vast areas is shown elsewhere in this paper. The present deplorable condition of the southern pineries is directly traceable to this source. The only excuse for periodic burning is that it reduces the severity and damage of fires, which it is said are bound to start accidentally if not set intentionally. This, however, is not necessarily true, provided careful and systematic measures are taken to prevent and promptly control all fires.

C. PREVENTION AND CONTROL.

All experience goes to prove that damage by forest fires is practically preventable. This stage of development has already been reached in Europe. For example, of 7,000,000 acres in Prussia, an average of only 1,400 acres, or one-fiftieth of 1 per cent, was burned over each year during the period from 1868 to 1895. This forest contained extensive areas of dry, sandy, pine land, where the fire danger was very great. In the mountainous forests of Bavaria, between 1877 and 1881, only 1 acre in 13,167, or seven one-thousandths of 1 per cent, was burned over. That the same results will in time be

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obtained in the United States there is no reason to doubt. Many beginnings along this line have in fact already been made, and the results so far obtained, even though frequently on a small scale, offer every encouragement for satisfactory results from future efforts. It must, of course, be remembered that conditions in Europe and in the United States are very different. The large population of the peasant class makes it possible to utilize even the smaller branches and the leaves, thus for the most part removing the medium by which fires are transmitted from one part of the forest to another.

The discussion which has preceded regarding the various forms of damage resulting from forest fires shows conclusively that the nation as a whole can not afford to sustain the immense annual loss which has resulted from this source since before the beginning of the first settlements. The great difficulty has been that while this fact has to a certain extent been recognized by a few individuals and by the Federal Government, it has never yet thoroughly penetrated the consciousness of the people as a whole. Federal legislation has been delayed until vast areas have been devastated almost beyond repair; only a comparatively small number of the States have taken action, and even then the action has for the most part been totally inadequate to meet the situation; in only a pitifully small number of cases has definite action been taken by private owners, whether corporations or individuals. A beginning has, however, been made, and with the inevitable decrease in our timber supplies and the consequent rise in prices will come a constantly increasing realization of the absolute necessity of conserving what remnants are still left of our once magnificent forests. In proportion as this realization grows will definite steps be taken for the perpetuation of the forest upon lands not more valuable for other purposes. Experience in this country, as well as abroad, demonstrates beyond a doubt that the best business policy is one of prevention. The old adage that "an ounce of prevention is better than a pound of cure" holds here absolutely, for two reasons: (1) The cash outlay for preventing forest fires is actually less than for fighting them after they have once secured a start; unquestionably some fires are sure to occur, but when proper precautions have been taken they can be extinguished in their earlier stages at a small cost as compared with the outlay necessary after the fire has gained headway; (2) under the policy of prevention the various kinds of damage already enumerated are for the most part avoided. The saving thus secured is almost without exception many times greater than the cost of protection. To wait until the fire occurs before taking action is to lock the stable door after the horse is stolen.

Fire measures may be classed under three heads: Administrative, legislative, and educative. The aim of the second and third is to secure a more general adoption of the first.

(1) ADMINISTRATIVE MEASURES.

PREVENTION.

Of administrative measures for the prevention of forest fires, the most effective are: Patrol, brush burning, and judicious grazing. For the control of fires the best measures are: Fire lines, back firing, the construction of roads, trails, and telephone lines, and the use of lookout points and observation towers.

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PATROL.

Of preventive measures by far the most important is patrol, since without it the others can prove of but little avail. The necessity of maintaining a regular patrol during the fire season can not in fact be overestimated. To leave the extinguishment of fires until they have grown to such proportions that they attract public attention is to defeat the object sought, since by that time the damage sought to be avoided will already have taken place, at least in part. The superior efficiency of a well-organized, paid fire patrol over volunteers or local officers appointed as fire wardens has been thoroughly demonstrated wherever it has been tried. The size of patrol districts depends first upon the funds available for the purpose, then upon the topography of the country, the amount and character of the timber, the amount of combustible material on the ground, the character of the season, the amount and sources of fire danger, and the efficiency of the patrolman. On the national forests the area of ranger districts varies from 40,000 to 200,000 acres, the former figure applying to the southern California forests, where there is extreme danger from fire and where the importance of the forest and ground cover as a watershed protection is greater than anywhere else in the United States.

In connection with the prevention of forest fires by patrol the following statement by Col. W. F. Fox, of the New York State Forest, Fish, and Game Commission, is of interest as showing the difficulty presented by one phase of the problem in the United States:

> The problem presented by the railroads is the most serious of all. We hope now to compel them to patrol their roads thoroughly during the dangerous seasons. Still, railroad patrols will not entirely eliminate the fires caused by locomotives. Even if we were to put them on one man to a mile, a fire could start between two of them in a dry time and attain dangerous headway before it could be noticed. There are only two remedies for railroad fires:
>
> 1. The forest floor along the line of the railroad must be kept as clean as in Germany.
>
> 2. The companies must use petroleum or electricity on their locomotives.
>
> The time has come when the State of New York has got to choose between its railroads and its forests. I am satisfied that we can not have both unless some stringent measures are enacted.
>
> As you are aware, the German forests are traversed by railroads to as great a degree as our own. Their immunity from fire is due to the fact that there is nothing on the ground aside from leaves that will burn; but the forests along our railroads are so filled with inflammable material on the ground that in a dry time a spark is very apt to flash them. During the drought of last year we were about as helpless in the matter of railroads as the superintendent of a powder mill would be if he allowed visitors to travel through his works, each one with a lighted cigar.

BRUSH BURNING.

In general, the hottest and most difficult fires to control are those which occur in the slash resulting from old lumbering operations. The removal of this menace is essential to the success of any operation looking toward the perpetuation of the forest. Of the various methods of reaching this end, one of the most effective is the burning of brush or slash either at the time of the lumbering operation or at its conclusion. Unfortunately, experiments to determine the practicability and cost of this method have, with very few exceptions, been carried on only upon the National Forests. The following statement is taken from the Forest Service circular entitled "Sug-

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gestions for the Disposal of Brush in the National Forests," by J. S. Holmes:

The piling and burning of brush on the National Forests has been required for the purpose of fire protection, but experience has shown that it is not always advisable. Every case should be considered separately and the question of brush disposal settled according to the special needs of the area in question.

Advantages of Brush Burning.

The greatest advantage of brush burning is the protection it gives against fire. In many cases brush burning is the only practicable safeguard against fire. After the average lumbering operation the ground is covered with slash, scattered about or piled, just as the swampers have left it. This, in the dry season, is a veritable fire trap. Probably 90 per cent of all uncontrolled cuttings are burnt over, which retards the second crop at least from fifty to one hundred years and perhaps permanently changes the composition of the forest. Fires may be set by loggers while still at work on the area or several years after by lightning, campers, or locomotives. By piling the brush and burning it in wet weather or in snow, when there is no danger of the fire spreading, all inflammable material is removed, and the second growth can come up without serious risk of being destroyed. Even where only part of the brush is burned and the rest is piled, as when the piles in open places, along ridges, streams, or laid off lines are burned, very much is gained in case of fire, since these cleared lanes form bases from which a fire may be fought.

Besides lessening the danger from fire, brush burning has certain minor advantages. When the brush on the ground is removed it is much easier for rangers and others to ride or walk through the forest. This may be very important in case of a fire or in rounding up cattle. It is also much easier to cut and handle ties, cordwood, or other timber which may later be taken from the cut-over area if the slash is out of the way. By piling and burning the green brush as it is cut from the trees by the swampers, as is now being done in Minnesota and parts of Montana, the ground is cleared and skidding is made easier and cheaper. Again, careful piling and burning of brush improves the appearance of the forest. There is nothing much more unsightly than a recently cut-over area where no attempt has been made to dispose of tops and lops. Near towns or resorts and along roads or streams frequented by tourists this point should be carefully considered, but as a general rule the utility of the forest should not be sacrificed for beauty.

Disadvantages of Burning.

The disadvantages of burning brush are many and, with the one exception of protection from fire, far outweigh the advantages. If protection can be had in some other way, as with more efficient patrol service or more stringent laws, the practice should in many cases be abandoned. In many places, especially in the yellow-pine type, the best, and often the only, reproduction comes up under a fallen tree top or other brush. Where there is little of the old stand left, the straggling open top protects the seedlings from the direct heat of the sun. Yet brush not only protects the seedlings from the sun, but, what is more important, the leaves and broken twigs form a cover which retards evaporation of moisture from the soil. Over the greater part of the West the soil dries out very rapidly during the dry season, and this seriously retards or even prevents the growth of seedlings. Even in the moister regions, such as that of the Engelmann spruce type, it is very necessary to conserve the moisture in the soil after logging to prevent the remaining trees from being killed through lack of soil moisture. A third reason why seedlings so often come up only under the down tree tops is that they are protected from stock. Next to drought, sheep are perhaps the most serious menace to reproduction, and though it would be best to keep all stock off the area for several years after logging, in many cases this is not practicable, and on many areas the leaving of the tops on the ground is the only way to protect reproduction from injury.

In many places after the timber has been cut off gullies and washes start in the old wheel ruts, log slides, etc., and these and other forms of erosion can best be prevented by leaving the brush on the ground, either laid in the incipient washes or scattered over the soil that is likely to wash. Brush burning de-

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stroys the valuable soil cover, and on the spots where the piles are burned the soil is loosened, which renders it even more liable to erosion.

It is well known that where the forest is burned each year the soil becomes poorer and poorer, because nitrogen, the chief fertilizing ingredient of the soil, is given off in the smoke, and only the mineral elements go back to the soil in the ashes. And, what is more injurious, the humus, i. e., the decomposed vegetable matter in the top soil, is destroyed. In burning brush after logging all the fertilizing and humus-forming leaves and twigs are destroyed just when most needed, for another good crop of leaves can not be expected for many years.

The burning of brush not only removes from the soil its natural manure, but renders it unfit for the germination and growth of seedlings. This is especially true of Engelmann spruce. Douglas and white fir also in the Southwest will not come up after fire. The area of ground covered by piles for burning varies according to the type and to the density of the forest, but an average of from 5 to 10 per cent of the total area is thus made nonproductive. If full reproduction could be procured on the rest of the area, this would make very little difference, but where reproduction is scattered and hard to procure, as in the Southwest, it would probably make considerable difference in the final stand.

The added cost, both to the lumberman and to the Government, is another argument against brush burning. The cost of piling brush has varied all the way from 15 cents to $1 or more per thousand, with an average of 40 or 50 cents, while the cost of burning may be from 5 cents to 25 cents per thousand, averaging about 15 cents. By abandoning the practice of brush piling, this 60 cents a thousand will not be entirely saved, as is claimed by some, for the brush will still have to be lopped and disposed of in some other way, which will cost, it is estimated, at least half as much as piling and burning. But even a saving of 25 or 30 cents a thousand is a strong argument against the practice.

Thus, from a silvicultural viewpoint, the disadvantages of brush burning far outweigh its advantages. Yet, as a general policy, it seems unwise, until other methods have proved their efficiency, to abandon brush piling and burning to any great extent at present. The fire danger is a known quantity, and though it is being reduced each year it is still a menace. Therefore changes from the present practice should be made with caution. Brush piling and burning is certainly not advisable in all cases, and extensive experiments should be made to determine what is the best method of brush disposal for the different types and conditions.

Brush Piling and Burning.

The cost of piling varies with the cost of labor, the methods of logging, the type, the topography, the kind of trees cut, and the time of year it is done. A few figures will illustrate this variation. In the yellow-pine type in Montana an addition to the swampers' wages of 15 cents a thousand would, it is said, enable them to pile the brush, as they have to handle it anyway. Usually, however, the piling is done by a separate crew. Much of the work is thus duplicated. In yellow pine in the Southwest, brush piling costs from 45 to 50 cents, while in Montana it can be done for 25 cents. One operator in lodgepole in Montana says it is cheaper for him to pile than not to, because he can get his skidding done so much cheaper, yet on other operations it has cost from 50 cents to $1 a thousand, depending on how thoroughly it is cleaned up. In the sugar-pine yellow-pine type of California, the cost of piling averages from 25 to 35 cents, while the cost in the Douglas fir type, in Montana and Idaho, averages about 40 cents, and in Englemann spruce type the cost is only about 25 cents a thousand. It is certain, however, that the cost of piling will everywhere be materially reduced when the operators begin to look on piling as part of the swampers' regular work and not as an entirely separate job.

Dry brush should never be burned during the dry season, unless absolutely necessary for the suppression of an insect invasion. Green brush in some places may be burned at any time, but as a rule it is unsafe to burn it in dry weather. The best time to burn brush is in the fall, just after the first snowfall. Then the piles are dry, and there is no danger that the fire will get beyond control. Brush may also be burned at the beginning of or during the rainy season, when the ground is damp enough to prevent the fire from spreading, and the brush dry enough to burn readily.

The cost of brush burning varies like the cost of piling. It varies even more in the same localities, with weather conditions and methods of piling. Brush that can be burned for 10 or 15 cents a thousand at a favorable time, as just after the first snow, will cost 5 or 10 times as much to burn in dry weather, or

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when the piles are very wet. Brush can be burned more easily the first fall after cutting than it can the second year, when many of the leaves have fallen off. Brush burning has been done for 13 cents a thousand in lodgepole, in the Medicine Bow National Forest, while it has cost 22 cents in similar timber in the Yellowstone, and estimates of 40 cents a thousand have been made for it in the Rockies. It is generally admitted that brush can be most economically burned by the same people who pile it. Recently several contracts have been made in which the purchaser of the timber is required to pile and burn the brush under the direction of forest officers, as has been the practice in the Minnesota forest for some time. This will lighten the total cost, and when the weather allows the brush to be burned, as logging proceeds, the cost of burning will be offset by the subsequent reduction in the cost of skidding.

Piling Without Burning.

Brush piled properly, even though it is not burned, is a great protection to the forest. Inflammable material is removed from among the living trees, and should a fire occur it would be much easier to fight. This is especially true where reproduction is dense. Where openings are scarce piles should be made in the most open places, and may be larger than those made to be burned.

Ground Burning.

Where clear cutting is practiced and fire assists the reproduction that is wanted, ground burning is sometimes advisable. The slash is left scattered as in primitive lumbering operations, and after an efficient fire line has been made around the area it is burned off clean. The fire line should be thoroughly cleaned up before the area is fired. Great care will have to be exercised to prevent the starting of a crown fire, which can not be controlled even with wide fire lines. The brush should usually be fired against the wind, and should the wind change after the fire is started the brush on the opposite side of the tract should be back fired. This method is the only practical way to secure reproduction of desirable species in some parts of the country.

Lopping and Scattering.

Where it is best to lop the tops and scatter them over the ground, the lopping should be done thoroughly, so that the top logs and larger branches will lie flat on the ground. If the object is to prevent erosion, the brush should be scattered or roughly piled where washing is most likely to occur. If washing has already started in wheel ruts, log slides, etc., brush should be laid in these as compactly as possible. If good-sized gullies have formed, it is usually better to put the brush in them in compact piles, filling them from side to side, than to scatter some brush all along them. If the chief object in scattering the brush is the conservation of moisture, it should be scattered evenly over the ground within reasonable distance of where it is felled, care being taken to keep the brush at safe distance from living trees. Where brush is scattered, fire lines should be made at intervals by piling and burning the brush in lanes 200 or 300 feet wide. This diminishes very greatly the danger from fire, by isolating different areas in the forest and giving places where back firing can be started. The cost of lopping and scattering brush in this way has not been determined, but it is thought that it can be done for from 50 to 75 per cent of the cost of piling and burning.

Grazing.

The fact should not be overlooked that judicious grazing in coniferous forests is a benefit rather than an injury. Not only does it not prevent reproduction where the range is not overstocked, but it aids very materially in making it possible to protect the forest from damage by fire. Where the range is not utilized, or incompletely so, a thick covering of dead grass accumulates on the ground, which burns readily, carrying the fire over large areas, destroying young growth, injuring middle-aged and mature timber, and setting fire to any inflammable material that may be within reach. Where there is a

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sufficient amount of dead timber on the ground to hold fire, the living trees are usually killed and partial or total loss of the property results. On the national forests throughout the Western States protection from fire has been most difficult on grazing lands which could not be utilized on account of lack of springs or streams for stock-watering purposes. A good example of the damage resulting indirectly from this condition is the Paulina Mountains fire, which burned from August 2 to 23, 1908, in the Deschutes National Forest, Oregon. There is no surface water in or near the vicinity; it has, therefore, not been possible to utilize the range, and as a result the ground was covered with a heavy covering of dead grass under the growing vegetation. The cause of the fire is attributed to lightning.

The region where the fire occurred is remote from settlement and before help could be secured to fight the fire it had assumed great proportions, covering a front of 40 miles. It was 50 miles to a base of supplies and 16 miles to water. Men had to be brought distances varying from 50 to 150 miles, and over 100 were employed in fighting the fire. Though 240,000,000 feet of green yellow pine was killed and 3,000,000 feet of dead pine destroyed, an immense amount of timber was saved that would have been destroyed but for the efforts of the forest officers. The point, however, is that had the region been moderately grazed the large amount of dry grass would not have been present on the ground, the fire could not have traveled as it did, and the damage would have been but a small fraction of that which actually occurred. An additional point is that where stock is grazed the presence of men to care for them is required; and these men are invaluable in aiding forest rangers and local residents, if there be any, in discovering and extinguishing fires before they gain headway. The development of water on dry ranges, in the form of wells or springs, and its retention in troughs or reservoirs, for the use of stock, would go a long way toward making possible the prevention and control of forest fires in remote and inaccessible regions. This is a strong argument in favor of the policy which the Forest Service has adopted of developing the range as fast as the necessary funds can be made available.

Removal of Débris.

In many cases it is entirely practicable to prevent damage to standing timber in case of fire by removing the combustible material from the base of the trees.

Mr. T. B. Walker, one of the largest owners of timber lands in northern California, gives the following description of the method adopted upon some of his tracts:

> In the spring of 1902 I sent a crew of men into a large tract of timber on the headwaters of Fall River, in northern California, who were known as the "fire brigade." They were fully equipped with teams, camping outfit, tools, etc. After establishing their camp in a particular locality the section was divided into 40-acre tracts, and each two of eight of the men went upon four separate divisions and systematically began the work of clearing away around the foot of each tree all the needles, leaves, cones, brush, limbs, pieces of stubs or logs that lay against or near the roots of the tree. Each was supplied with tools, one carrying a shovel and ax, the other a shovel and crosscut saw. With the shovel they scraped away all the loose materials to the distance of several feet from the tree, and with the ax and saw they chopped or sawed any larger pieces, which were then rolled away. All trees having burned spots or hollow places, after clearing out and away from them all the leaves and loose materials,

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loose dirt was thrown against the spots and the hollow places filled, so that when another fire came they would be protected. The bark of these trees is very thick and furnishes a very natural protection against the running fire. It is only where an extra amount of fuel is accumulated against the side of one of them that it can be burned through sufficiently to injure the tree. But when a burned spot is once formed the pitch runs out and forms a coating or bunch that is very combustible when fire again comes, if it reaches to it. But by means of clearing away the material and covering up the pitch and hollow spot the bark will re-form and cover the damaged place, so that future fires will do no damage until another accumulation of fuel, as in the original burning.

There is hardly any such thing as a sweeping fire in California in the uncut forest that consumes or destroys any considerable number of trees. It is only through a gradual process of damage at the root of the tree in the manner above specified, where, after a burned spot is once formed, the next fire enlarges it through the large cavity formed, which in the course of years enlarges so as to leave only a shell of the trunk of the tree, and finally to so burn it away that it falls and throws a large top with its leaves and cones alongside of other trees.

This great amount of fuel renders the trees against which it has fallen liable to the same kind of process of gradual and sometimes immediate destruction when the next fire occurs. The fire brigade is expected to clear away all such fallen tops to whatever extent they endanger other trees. A tree may be injured many times by having spots burned where all of them may gradually be healed over without much permanent injury to the tree, and where a spot is formed is enlarged from time to time by repeated fires, it may take a great many years, a quarter or half a century, perhaps, or more, to destroy the tree.

Now, at any time from the foundation of the burned spot to the time that the tree is burned down, this process will protect it from further damage, and if there is enough wood to keep the tree from blowing over, the process of repair and growth will be resumed as soon as the ravages by fire are stopped.

METHODS OF FIRE CONTROL.

Fire lines are one of the most effective means of controlling serious fires. Their value, however, depends largely on the character of the ground cover, and in some regions their use is not advisable. Moreover, their width, location, and manner of construction vary with local conditions, all of which must be decided by local study on individual tracts. In the southern pineries, and wherever the aim is to stop grass fires, the main fire lines should be plowed strips from 10 to 30 feet wide, with a narrower parallel line some 40 to 100 feet distant. The space between the two lines can often be burned over to great advantage. In timber land with a brushy undergrowth fire lines are usually impracticable, but if made should be 40 to 100 feet wide to be at all effective—the wider the better. Fire lines on cut-over lands are often of high value, and should be of varying width in accordance with the condition of the inflammable ground cover. Cleared or burned strips 100 or more feet wide are often essential. In pure brush growth, such as is commonly known as chaparral in California, fire lines are very essential, if fires are to be quickly controlled. They should be widest in "saddles" and where the brush is densest, and of minimum width on the crests of sharp ridges. A width of from 15 to 50 feet or more is usually advisable. The brush should be cut off close to the ground and the roots grubbed out if possible. All such lines should be connected with trails.

Much depends on the location of fire lines. They should not be expected ordinarily to stop a fire, but rather serve as an indispensible vantage point from which to back fire or to beat out flames which jump over. Fire lines should take advantage of topographical features and be located where fires are naturally reduced in their progress or severity. This is usually on the crests of ridges or where

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the brush or forest is open or the ground bare. An important consideration in all fire-line construction is to plan for the removal of all dead stubs for a distance of at least 200 feet on each side. In case of fire these stubs ignite readily, and the wind carries sparks and firebrands from the tops for long distances.

Closely associated with fire lines is the question of back firing, and plans, based on local conditions, should be made for this use of fire in fighting fire. Back firing should be resorted to only when absolutely necessary, and never save under competent supervision.

If fire should get a good start in old slashings or logging works, it might be useless to make a fight until it reaches a skid road or stream, or possibly green timber. If it can not be checked until it reaches green timber, it is best to go back far enough into the timber so that the heat and smoke will not drive out the fire fighters. If there is no road or skid road in the timber where a stand can be made, and if the ground is fairly level, a trail should be cut around the head of the fire from 10 to 20 feet wide, and brush, rotten wood, moss, etc., cleaned out and piled on the side next to the fire. A back fire should then be started. In back firing it is most essential to see that the fire does not creep or blow back across the trail. It is dangerous to back fire unless enough help is available to control it. When fire strikes the green timber it will probably burn some tree tops, but when the tops and brush along the edge of the timber have been burned, it will die down and creep in the moss and brush on the ground and it can then probably be stopped at the trail. If, after the fire has died down, there are any dead snags left standing with fire near the top, they should be cut down.

Fire rushes uphill, crosses the crest of the hill slowly and is more or less checked in traveling down. If the fire is running uphill, especially with the wind behind it, it may be impossible to handle it until it reaches the top. If such is the case the best place to cut the trail is just beyond the crest of the hill, where there will be less smoke and where the fire will naturally be checked in running downhill.

The fire should be watched until it is entirely out. The first fire burns above the surface of the ground, and there is apt to be fire left smouldering underneath for days. The trail should be watched as long as smoke can be seen, and as soon as it cools down what fire there is left should be dug out. Dry sand or earth is usually as effective as water (and much easier to get) when thrown on a fire. Fires burn faster in the heat of the day and are more easily controlled at night or in the early morning.

In all plans of fire protection provision must be made for an emergency fire-fighting force. The labor arrangements at the mill or in the camp must be studied, and a force of competent men selected who can drop everything at a moment's notice and proceed to a fire. This force should be made up of men who can be spared temporarily without shutting down any part of the mill or interfering with logging operations. One or more experienced men should be designated to act as leaders of the fire-fighting squads.

Plans should be made for storing suitable fire-fighting tools at readily accessible points. One set should be at the mill or camp where the emergency force is working, and others in settlers' cabins or special tool houses on different parts of the tract. The location of

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these sets of tools should be determined by a field study. The tools usually needed are axes, spades, rakes, and buckets, and canteens for the personal use of the men.

Where fires frequently start along logging railroads it has occasionally been found advisable to equip a flat car with a water tank and force pump for use in extinguishing fires near the track. This, however, is rarely necessary, but should be considered. A more effective means of preventing the spread of fire from locomotives is to clear or burn a strip 200 or more feet wide on each side of the track. These lines should be made part of the general fire-line system.

Trails are indispensable on ordinary forest tracts, in order that all parts may be readily accessible. In connection with fire protection they are needed by patrolmen, and in order that fires may be reached without delay. Wherever possible trails should be laid out with the contingency in mind that they may at some later date be developed into roads.

On large holdings the location of lookout points should be decided upon if their use is advisable. They should be located, if possible, on the regular trails. The value of lookout stations will be determined largely by the topography and size of the tract. They are naturally of the greatest value in mountainous regions and practically useless in a level country. Sightly points should be selected for these stations, and provision made when advisable for cabins and for permanent observers during the season of fire danger.

In connection with the trails and lookout stations the construction of telephone lines is of great value, since by this means it is possible to secure help quickly in case of fire without the necessity of the patrolman leaving his district for that purpose. The existing means of communication, the need of call boxes along the trails, and the necessity of giving the men at lookout stations direct communication with headquarters should be the determining factors in locating telephone lines.

FIRE FIGHTING BY REGIONS.

It is impracticable here to include detailed and definite instructions to cover local fire-fighting problems; on the other hand, conditions so vary that no set of rules can be given that will apply universally. Eastern and western forests differ, and there are regional differences within these two great areas. Altogether there are eight distinct areas as regards forest fires, each of the eight having peculiar features that distinguish it from the others. Those in the East include the spruce forests of the Northeast; the woodlot that is characteristic of the New England and Middle Atlantic States, and the Ohio Valley region; the hardwood forests of the Southeast, including particularly the Southern Appalachian region; and the coastal pine belt of the Southeast and South. Then there is the Lake States region, and in the West the Rocky Mountains, the Pacific Northwest, and California, particularly the southern part.

Fighting fires in the Northeastern States.—The principal forest regions of the Northeast are characterized by dense stands of conifers, and by open hardwood stands with heavy undergrowth. The ground is covered, for the most part, with a thick layer of humus or "duff," which may carry a fire for a long time and not show it. Forest fires in this region are most common in early spring—April and May—

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but are likely to occur also, though with less frequency, in the early fall—September and October. In the spring the ground is covered with a thick layer of dead leaves. With the advent of the warm sun and the south wind these become so dry that they ignite easily and burn quickly, with a blaze fierce enough to communicate itself to the dry refuse of old cuttings and to dead trees.

Two classes of fires are recognized in this region, ground and crown fires. Where there is only a light surface fire, the most common and least expensive way is to put it out with green branches, wet sacks, or wet blankets. This method is effective if the fire is attacked early enough, and if great care is used to see that the fire is actually all out and not driven from the surface down into the duff.

Where the fire is more severe and there is plenty of water, a common method is to institute a "bucket brigade," whose members pass buckets of water from a stream to the fire line. The water is rarely used against a main fire, because there it would be largely wasted, but rather to quench numerous small blazes that are started by sparks from the big one.

Where water is unavailable, sand or earth is thrown on the small blazes. This is harder work, but is more effective, unless the earth used is composed of humus or vegetable mold. In that case it apparently smothers the fire, but eventually adds fuel to it.

The best way, however, to stop a ground fire, and often the only sure way, is by trenching. This is simply digging down to the mineral soil and throwing the dirt toward the fire. This is a costly and a hard task; to be successful it must be done so far ahead of the fire that the mineral soil can be reached before the fire gets a chance to cross over. A faster method, but not so sure, is to dig holes in a line a rod or so apart and spread the dirt along the ground between the holes. Sometimes furrows may be plowed or fire lines may be cleared ahead of an advancing fire.

Crown fires can not be attacked directly unless the fire is small and the conditions unusually favorable. The flames travel so rapidly and jump such long distances that nothing can be done, except a long way in front of them. Lines may be cleared along the edges of the fire to prevent its spread laterally. Back firing is an extreme to be made use of when all other methods fail, and then only under the direction of an experienced person. The danger, particularly when there is a wind, is that the back fire may spread and add its fury to that of the original fire. When it can not be started from and held to a fixed line and forced back toward the main fire, a modification may be adopted to burn over an extended area far ahead of the on-coming blaze, which will go out from lack of fuel when it reaches the burned-over portion. In order to minimize the danger of having the precautionary fire get beyond control, the area to be burned may be divided into small sections, and each fired separately. This plan is analogous to the dynamiting of blocks of buildings to stop a city conflagration, and should not be resorted to except in extreme cases where valuable property is at stake.

Railroads in the Adirondacks use special devices for fire fighting. The Rumford Falls and Rangeley Lakes Railroad in western Maine has hose of extra strength, which, attached to a locomotive's pump, sustains a pressure of 90 pounds, sufficient to throw a half-inch stream about 100 yards. The jet of water trained on a tree is strong

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enough to tear off the bark, and will shatter burning stumps. It has been used with very satisfactory results.

The fires in the Rangeley Lake region of 1903 were generally fought by crews of about a dozen men, whose leaders had a code of signals by which the work could be correlated and reenforcements sent to points of particular danger. Usually the crews were called out at 3 o'clock in the morning and continued fighting until 1 o'clock in the afternoon, when the wind was so strong that no work could be done, except by scouts ahead who kept little fires from starting in advance of the big ones. Then in the evening when the wind went down with the sun, and the fire largely changed back to a ground fire, work would be resumed for a few hours until the night winds came up.

Protection of the woodlot.—It has been estimated that one-third of the total stand of timber in the United States is in farmers' holdings. The woodlot is thus an important part of the forest resources of the country.

The successful protection of the woodlot from fire requires three conditions: Proper organization, efficient watching, and facilities for fighting fire. By organization of a woodlot for fire protection is meant the establishment of such a condition that fires may most easily be prevented from starting, and that fires which do start may most readily be extinguished. The measures usually practical in this woodlot organization are, first, the disposal of tops and dead brush, and, second, a construction of fire lines. A fire in leaves may be put out entirely, but if tops, old logs, and snags lie scattered about, the fire may smolder in them for a long period and remain a constant menace after the main fire is out. It is especially desirable to prevent the accumulation of inflammable trash near roads and paths where smokers and hunters are liable to set fires.

The best fire lines for the woodlot are roads and paths. Their first purpose is to make the different parts of the woods readily accessible. In a city the effectiveness of a fire department depends on the degree of quickness it can reach a fire. In the same way, the forest traversed by roads and paths by which an incipient fire can be reached quickly is in the best condition for protection. Roads and paths will check an ordinary fire. Many fires are absolutely stopped by a dirt road, and small fires will not cross a dirt trail. If back firing is absolutely necessary, it is best done from a road or path. An opening in the forest may be a vantage point from which to fight fires, but as a check to fire it is only slightly better than no opening unless cleared entirely of inflammable material. Ordinarily, if the roads are adapted to use as fire lines, and if there are roads or trails near those boundaries where danger exists, the woodlot is well organized.

Constant watchfulness during the danger season is absolutely necessary. A woodlot that is not watched is not protected. Usually a woodlot is in close proximity to the cultivated portion of the farm, and it involves very little additional trouble to watch for fire. During very dry periods it is sometimes desirable to actually patrol a lot two or three times a day.

It is necessary not only that the fire be discovered quickly and reached quickly, but there must also be ready facilities for attacking it. The watcher must have the necessary tools readily accessible,

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i. e., axes, shovels, rakes, and water pails. He should also be able to secure help quickly in case he can not handle the fire alone. The best system is to have a cooperative understanding among a group of neighbors to assist each other in case of fire.

The South.—Broadly speaking, the fires within the mountain region of the South are surface fires which consume only down timber, young growth, slashings, leaves, and other forest litter. These fires are set by careless hunters, by sparks from locomotives and sawmills, or intentionally by cattle owners to improve (as generally erroneously believed) the spring grazing.

Whatever the cause of the fire, each owner of forest land should use every effort at his command to extinguish the fire at the earliest possible moment. If taken in time at the early stages, one man can often beat it out with brush or surround it by raking away the leaves. If delayed a short time, the assistance of neighbors will be required, but usually the efforts of such organized fire fighters are directed not so much to extinguishing the fire as to turning it aside from the farm buildings, fences, or dry crops of the owners directly interested at the time.

In a mountain region large and small owners in a section of country, say of a county or a watershed of a stream, should combine for protective measures in preventing and fighting forest fires within the section. Such an organization should employ a fire warden and one fire guard for about each 10,000 acres of land. The duties of the fire guard would be to patrol or keep a lookout from vantage points during the dangerous season of early spring and fall and seasons of drought. Behind the fire warden and guards every owner of timber land within reach of a reported fire, with his employees in logging camps, sawmills, farms, or tenants, should be prepared to go to the fire immediately and stay with it until extinguished.

Fire usually travels slowly in the hard-wood region of the mountains, and a line of men with rakes, shovels, and brush should easily control any ordinary conflagration. With a brisk wind and a rapid fire the line of men should retreat to the next stream, dry run, or crest of a ridge and make a fire line about 5 feet wide by raking away the inflammable litter. Back fires should then be set along the side of the line toward the fire, with the men keeping watch to see that it does not cross the line.

The cost of this system of protection should be distributed among the owners of timber land within the protected areas in proportion to the acreage of their respective holdings. Where patrol is only necessary for short periods two or three times a year the expense should not be more than a fraction of a cent per acre, and is more than justified by the amount of timber it may save from fire left to run until it burns itself out or is extinguished by a chance rain storm.

Throughout the rolling hills of the Piedmont Plateau, contiguous bodies of large timbered areas are infrequent, and the timber is generally confined to large wood lots and pasturages of plantations. Here it is more clearly the problem of the individual owner to take care of the fires arising on his own land, but, again, the cooperation of timber-land owners in each community or settlement for mutual protection would be a thousand times more effective in preventing the disastrous spread of a small fire, neglected, perhaps, for the reason that it was not on the land of the one who observed it.

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In the turpentine belt or longleaf-pine region dry grass in the open woods is fired every winter to improve the grazing and to prevent fires later on during the turpentining season. In this region the custom of annual burning is more firmly established than in any other forest region. The problem of fire protection is made more difficult by the fact that natives hold to the custom as an hereditary right, lumbermen are indifferent, and turpentine operators care only to protect their four crops of turpentine in the easiest manner.

The problem resolves itself into a remedial campaign of education relative to damage by forest fires, enactment and enforcement of suitable state fire laws, creation of an organization of state fire wardens and guards who will do something, and persistent personal effort of each state forester in stimulating public sentiment against setting fires in woodlands.

If enough interest can be aroused, owners of adjacent timber lands may be prevailed upon to band together for fire prevention and protection, each defraying his proportional share of the expense.

Fire protection in the Lake States.—With the possible exception of the southern pine region, there exists nowhere a greater apathy regarding forest fires and less real effort to prevent them than in the Lake States—Minnesota, Wisconsin, and Michigan—this in the face of the fact that a major part of the property fire loss and more than three-fourths of the deaths have occurred in this region. Disaster, such as that of 1908, does not seem to offset indifference and ignorance; even where state laws are good, they are useless unless enforced and supplemented by the efforts of landowners.

In the Lake States fires can for the most part be completely suppressed with reasonable expense. The most destructive fires always occur in cut-over areas of slash, and such fires may in a high wind spread into the crowns of young pine and balsam. So great is the danger of fire after logging that if fire protection is to be attempted, the tops must be burned. This can be done during the skidding, even with snow on the ground, by piling the tops on fires as the swamping progresses; or the tops can be burned early in the spring before the ground is dry enough for fire to run.

With the slash burned, subsequent fires will take the form of low surface fires consuming the dried grass, weeds, and small brush of from one to three years' accumulation. These fires must be absolutely prevented if a second crop of timber is to be grown.

To do this the owner must resort to two measures to supplement the state fire laws, namely, the employment of fire patrols and the construction of fire breaks.

Streams, roads, and even trails may be used as fire breaks. A high wind will drive fires across the best fire breaks, but small fires frequently burn out along a break or road. The purpose of breaks should be, not to mechanically prevent the crossing of a fire, but to give the fire patrol a chance to fight an advancing fire successfully.

The worst fires may be stopped along a fire break by back firing. It is, therefore, to supplement the efforts of the fire fighters that breaks should be made.

Where natural features or roads are absent fire breaks can often be cheaply constructed. On the sandy plains of the Michigan state forest reserves strips 20 feet wide are fully plowed, with no effort

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to grub the stumps, at a cost of $20 to $30 per mile. The first plowing lasts two years without renewal.

In hard-wood forests or white pine, with much underbrush, plowing is expensive and inefficient. Here two parallel strips may be cleared a few feet wide by brushing and raking, and the space between burned, the width being from 25 to 100 feet, according to the danger. Railroads should burn a strip along their tracks as wide as their right of way, and 200 feet would be safer.

A mounted ranger can patrol a township of land and is often called on to guard much larger areas. If on foot, there should be two and preferably three or four men to a township, depending on the value of the property to be protected. The larger and more compact the holding, the smaller will be the expenses per acre for fire protection.

For fire fighting in most of the Lake State regions water is not available. The long-handled shovel and the use of sand will be effective against ground fires. For the direction of a force of fire fighters, and for the subsequent handling of back fires whenever they become necessary, a ranger with some experience is indispensable. The employment of one or more of such men will have an educative and restraining influence in the matter of careless setting of fires. The total cost of fire protection by these means should not exceed 10 cents per acre annually on tracts of 10,000 acres or more.

Fire control in the West.—In the western part of the country, three different types of forest roughly differentiate the methods of fighting. These types may be described as the Rocky Mountain, the Pacific Northwest, and the California.

The Rocky Mountain region.—In the Rocky Mountains fire is much dreaded from the beginning of the dry season until the first storm that presages winter. Because of the character of the country it is particularly hard to locate a fire that is started. The column of smoke that appears to be just over the first ridge may prove to be many miles away past peaks and canyons. Where a fire gets started and it is impossible to extinguish it, as is generally the case, all effort should be centered on confining it to the smallest possible area, or to the area containing the least valuable timber or upon which the least damage will be done. It is practically impossible to extinguish a fire of any extent by the application of water, and wholly impossible to beat out one, as in the case of a grass or prairie fire. The only effective method in this region is trenching, which consists in the removal of all duff and litter down to the mineral soil, in a strip about two feet wide. It is, in effect, ditch digging, which may be done rapidly and with comparative ease by the use of shovels, on soil covered only with humus and free from brush and rocks. Upon ground covered with huckleberry brush and other similar growths, and where the surface is rock strewn, the task becomes slow, tedious, and difficult, and the shovel must be supplemented by the mattock and pick.

To make trenches immediately adjacent to the fire front is worse than labor wasted. It is unnecessarily hard on the fire fighters because of the heat and the danger from falling trees. Moreover, these trees falling across the trench carry the fire beyond it, and there is always the possibility of overlooking particles of burning refuse and limbs that will carry the fire ahead. The location of the trench then becomes a vitally important point, and one to which the

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man in charge must give his attention at all times. Fortunately, the wind can usually be depended upon to come from a definite direction during the daytime, with a lesser opposite motion at night, beginning about sunset, and not reviving until about 10 in the morning of the next day. No matter what the time of the day may be, the trench must be laid enough ahead so that the fire may nearly reach but not cross it at the time the wind falls and the air currents change in the evening. Then, if the plans have been correctly laid and all dead trees that might fall across it have been cut, all will be well when evening falls. The wind will be down to a mere breeze which bears against the fire which is now burning nearly up to the trench. Back fires should then be set to all inflammable material immediately along the trench on the side toward the fire. Close watch should be kept that the fire may not get back across the trench; carried by the night breeze, it burns slowly toward the main fire. The two meet and the hard work is over.

Trustworthy men should be left to make their camp and stay with the fire that is inside the segregated area. A patrol of several days or even weeks is necessary so that a passing wind shall not carry embers over the line to start fires anew.

While the fires in the Rocky Mountain region are usually termed ground fires, it is a fact that within a fire area the crowns of nearly all trees are burned, and the shooting of the fire into the air and the burning of a large crown are fraught with serious possibilities of danger. A sharp lookout must always be kept, and in nearly every case a patrol must be maintained far beyond the trench construction to make sure that sparks and brands do not ignite the forest ahead and thus put the fires behind the fire instead of in front of it.

Fire control in the Pacific Northwest.—In the Pacific Northwest forest fires seldom travel with great rapidity, because the trees are less resinous than in other regions, but the luxuriant growth and great accumulation of duff and fallen wood makes them exceedingly difficult to extinguish. The monetary and economic loss is great because of the density and value of standing timber.

Even more than elsewhere is care with small fires of the greatest necessity, for the deep layer of combustible material on the ground may hold them for weeks or months until favorable conditions of wind and dry weather fan them into destructiveness. It too commonly happens that the arrival of such conditions late in every summer not only increases the danger from fires started while they prevail, but brings about the spreading beyond control of innumerable small fires which have been smouldering unattended because not considered dangerous under previous conditions when they could have been put out with small effort.

Camp fires should never be built against trees, logs, or rotten wood, which may remain burning unknown when the camp is left. Fires for clearing land should never be set during the dangerous season without the permit required by law and careful observance of its stipulated safeguards. Such fires set before the close season should be entirely extinguished or brought under complete control before the close season begins. Especially should all possible communication of smouldering fire from the burned area be prevented by the cutting of standing dead trees within it and the clearing of an

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adequate fire line around its edge. Accumulations of débris near cabins, logging camps, roads, and railroads should be burned at safe times in spring or fall, under the foregoing precautions, so they may not feed accidental fires during dry periods. Railroads or logging engines operating without proper spark arresters should be reported to the state authorities.

The tenacity of fires in the punklike ground cover is peculiar to this region. A fire starting in June may burn till Christmas in an area of one-fourth of an acre if the season is wet, but if a dry spell comes it spreads with great rapidity. There are thousands of such fires every year which nobody bothers with because they look so harmless, but when the right season comes the whole country burns up.

California.—Methods of fire protection and fire fighting in California do not differ materially from those in any other part of the West, except that protection must be more thorough and fighting must be done more quickly on account of the extraordinary dryness of the forest and the immense financial interests at stake. The long, hot summers, often without a drop of rain from May until November, turn the ground cover and underbrush into the most inflammable kind of material, and fire, once started, leaps along with amazing rapidity. This is especially true in the southern part of the State. Here the rich irrigated citrus lands are wholly dependent for their water supply on the brush-covered mountains from which the streams come. The chaparral of these slopes is so dense, so high, so dry, and so altogether impenetrable that when a fire once gets a good start it is almost impossible to control it. More than that, a man's life is in danger if he fails to keep at a safe distance.

The best protective measure is to make a network of trails, roads, and fire lines so that men can get about easily to watch for fire and get to it quickly when it starts; then during the danger season keep a lot of men constantly moving about the mountains ready to extinguish the little fires just as soon as they start; and give them a good telephone system by which to summon help when needed. These men must be professional fire fighters and know their business.

The best results in fighting forest fires will never be obtained until the whole thing is organized. This means hearty cooperation between the Federal Government, the several States, the counties, cities, corporations, and private owners; it means good laws, vigorously carried out, and it means the expenditure of money, a great deal of it.

(2) LEGISLATIVE MEASURES.

Practically all the States have laws fixing civil and criminal liability for damage done by the careless or malicious setting of forest fires. Recourse to these laws is, however, rare even in the States where the most advanced forest policies have been adopted. In the South laws of this kind are absolutely ignored. A strict enforcement of existing laws would go far toward removing the existing ignorance and indifference, and would, after a short time, render further prosecutions for the most part unnecessary.

Of great value, where properly enforced, are the laws prohibiting the setting of brush or fallow fires during certain seasons of the year,

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or allowing of such burning only upon the issuance of a special permit by a duly authorized officer, the burning to be done at such time and under such conditions as will not endanger neighboring forest property. Laws of this kind have been enacted in a number of the more progressive States. The proper enforcement of laws of this kind in the East and Middle West would prevent the occurrence of from one-third to one-half of the fires which occur under present conditions. In a letter to the forester in 1904, Col. W. F. Fox, of the New York state forest, fish, and game commission, said, referring to the New York fire law:

> I attach the most importance to the section of our law forbidding the farmers from burning brush or fallows in certain months of the year. Since the fires of a year ago we have enforced this law strictly in regard to the infliction of penalties for its violation. By continuing these prosecutions faithfully whenever a farmer burns his fallow out of season, we can undoubtedly eliminate entirely this prolific source of evil.

Nearly all the States have statutes requiring the use of efficient spark arresters on railroad locomotives. In general, however, the enforcement of these laws has been exceedingly lax, and in many cases engineers have not hesitated to remove the screens or to punch them full of holes when the presence of the screens began to interfere with the draft of the locomotive. Many railroad companies equip their locomotives with spark arresters, not because they are required to do so by state law, but in order to avoid civil suits for damages. This is the most effective weapon to compel observance of the law.

Many of the States also have laws requiring the clearing and annual burning of strips along rights of way. In only a very small number of cases is any attention paid to these laws. Strict enforcement, in connection with the use of efficient spark arresters, would bring about a great decrease in the number of forest fires along rights of way.

The great difficulty with laws such as those mentioned is that they are useless unless means are provided for their enforcement. This brings up the last and most important of the legislative measures for the prevention and control of forest fires, namely, the provision for an executive force charged with the duty of administering the laws. Many of the state forest and fire laws look exceedingly well on paper, but are totally inadequate to meet existing conditions, simply because inadequate machinery or none at all is provided for their enforcement. It should be fully recognized that it is cheaper to prevent forest fires than to fight them. The Federal Government has set the example by the establishment of a system of patrol on the national forests under the supervision of the Forest Service. Wherever possible, similar action should be taken by the States for the protection of state and private holdings from destruction by fire. There are several features which are essential to a good state fire law. In the first place an executive head should be provided. This should be a man who is thoroughly familiar with fire problems and who is intensely interested in the work. In some States this position is very advantageously combined with that of state forester; in others the two are kept separate, the firewarden being a nontechnical man. A

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good salary should be paid in order to secure a competent man. Political appointments should especially be avoided.

The second essential is the appointment of local firewardens. In most of the States where the appointment of firewardens is provided for this office has been combined with that of some township official, usually that of supervisor. It is believed, however, that the better policy is to appoint as firewardens the best men available and to make the positions permanent. Township officials, as a general rule, have a brief tenure of position, owing to the popular belief in rotation of office. In many cases also the town officials are apt to be petty politicians who are illy fitted for the important duties of fire protection and the management of large bodies of men. On the rolls of the State of New York are men who have served as firewardens over twenty years. Under this system they acquire an experience not only in fighting fire but in the exercise of judgment, the handling of men, and the keeping of the necessary accounts with the town and State. By confining appointments to property holders and influential citizens—men of well-known integrity—there is no need to fear that the firewardens will start fires to provide themselves with employment. They are too much interested in keeping down taxes in their respective towns to furnish any basis for this fear.

Without exception firewardens receive payment for time actually spent in fighting fire. Whether they should in addition receive a fixed salary to cover such duties as making reports and keeping records is open to question. Col. W. F. Fox, of the New York state forest, fish, and game commission, states:

> We do not find it necessary to pay the firewardens any fixed salary, large or small. We have had no difficulty in getting good men who were willing to serve without pay except for time and services actually rendered. As a rule our firewardens are well-to-do people who have lucrative employment the year round and do not need any compensation except for such time as when they are obliged by circumstances to give attention to the work. This is fortunate, because we have so many forest towns in our State that a salary list of this kind would be so burdensome that the taxpayers would complain. This would be the case especially in the years during which no fires occur.

On the other hand, Prof. F. Roth, forest warden for the State of Michigan, states:

> Even a forest warden should receive some pay, independent of whether he fights fire or not, at least enough to justify his attending to such duties as making reports and doing a certain amount of patrol work.

This plan has been put into effect in New Jersey, where township firewardens receive $20 and the district firewardens $10 annually, in addition to the per diem compensation allowed for time actually employed in fighting fire. The New Jersey plan has been in effect but a short time, so there has not been sufficient opportunity to demonstrate whether or not it is superior to the plan in effect in New York.

The great difficulty with practically all the firewarden systems, as at present in effect, is that they do not make adequate provision for the prevention of fires. In many cases the laws, if carried out, would provide a force to fight fires after they are once started. In practice, however, a firewarden is seldom informed concerning a small fire, so that in most cases he does not begin work until the fire has reached

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such proportions that it becomes a costly task to put it out. What is needed in forest regions is a system of paid patrol during the fire season. Small beginnings along this line have been made in several of the States, but they are almost entirely inadequate to meet the situation.

(3) EDUCATIVE MEASURES.

These are of primary importance, because it is through them that the adoption of administrative and legislative measures is secured. The most effective is the dissemination of information concerning the causes and effects of forest fires, and the methods by which they may be prevented or controlled. The almost total lack of accurate information concerning the loss due to forest fires is a very serious handicap to the efficacy of this method. Were the extent of the damage in its various forms once fully realized the public could not fail to be aroused to the point of taking decisive action.

On the ground, a very effective measure is the posting of fire notices at frequent intervals through the forest, particularly at camping places and at points of entrance and departure of travelers. These notices should be printed on cloth or tin, or be in the form of signs painted on wood. Cloth signs are usually about 12 by 14 inches in size and are ordinarily tacked on trees. They should be made to attract attention by the proper use of large type. Experience has shown that better results are obtained where cooperation is requested than where threats are used. Information should be given as to existing state or federal laws, and a brief statement made as to the reasons why the prevention of forest fires is desirable. The fire notice adopted by the Forest Service for use on the National Forests was designed to fulfill these requirements. The following is a copy:

FOREST FIRES.

The great annual destruction of forests by fire is an injury to all persons and industries. The welfare of every community is dependent upon a cheap and plentiful supply of timber and a forest cover is the most effective means of preventing floods and maintaining a regular flow of streams used for irrigation and other useful purposes.

To prevent forest fires Congress passed the law approved May 5, 1900, which—

FORBIDS SETTING FIRE TO THE WOODS, AND FORBIDS LEAVING ANY FIRES UNEXTINGUISHED.

This law, for offenses against which officers of the Forest Service can arrest without warrant, provides as maximum punishment—

A fine of $5,000 or imprisonment for two years, or both, if a fire is set maliciously, and a fine of $1,000 or imprisonment for one year, or both, if fire results from carelessness.

It also provides that the money from such fines shall be paid to the school fund of the county in which the offense is committed.

The exercise of care with small fires is the best preventive of large ones.—Therefore all persons are requested—

1. Not to build larger camp fires than are necessary.
2. Not to build fires in leaves, rotten wood, or other places where they are likely to spread.

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3. In windy weather and in dangerous places to dig holes or clear the ground to confine camp fires.

4. To extinguish all fires completely before leaving them, even for a short absence.

5. Not to build fires against large or hollow logs where it is difficult to extinguish them.

6. Not to build fires to clear land without informing the nearest officer of the Forest Service, so that he may assist in controlling them.

This notice is posted for your benefit and the good of every resident of the region. You are requested to cooperate in preventing its removal or defacement, which acts are punishable by law.

JAMES WILSON,
Secretary of Agriculture.

(D) RESULTS ACCOMPLISHED.

(1) BY THE FEDERAL GOVERNMENT.

(*a*) NATIONAL FORESTS.

The increase in the efficiency of the national forest administration from year to year is strikingly shown by a comparison of the figures for area and value of timber destroyed during 1905, 1906, and 1907, as shown in the accompanying summary. The figure for 1907 was 42 per cent of that for 1906 and but 31 per cent of that for 1905. The percentage of total area burned over decreased from 0.66 of 1 per cent in 1904, before the Forest Service administration began, to 0.31 of 1 per cent in 1905; 0.094 of 1 per cent in 1906; and 0.14 of 1 per cent in 1907. The increase in area in 1907 is compensated for by the fact that all but 29,365 acres were grass fires, which destroyed no timber, while in 1906 the area of merchantable timber burned over was 52,374 acres. Thus in 1906 the merchantable forest burned over represented but one twenty-third of 1 per cent of the entire forest area, while in 1907 it was but one fiftieth of 1 per cent. These results have been brought about by the gradual increase in the number as well as in the efficiency of the rangers.

That the force is still much too small has been clearly demonstrated during the fire season of 1908. The season has, in general, been an exceedingly dry one, and fire losses over the entire country have been greater than at any time for many years. The expenditure of approximately $50,000 for fire fighting on the national forests has been necessary, in addition to salaries of forest officers under appointment, as contrasted with less than one-tenth of that amount during the preceding year. While the fire losses have been much heavier than during any other year since the forest service administration began, yet they are infinitesimal as compared with what was saved. It is estimated that of the 167,992,208 acres in the national forests, 75,000,000 acres contain saw timber of commercial size. The stand of timber on this area is estimated at nearly 400 billion feet board measure. At the average rate of $2.50 per M stumpage, the timber on the national forests thus has a value of $1,000,000,000. The wisdom of spending a reasonable amount of money for the protection of this vast property of the people can not be questioned.

The following tables show fire losses on the national forests since 1902, so far as statistics are available from the Forest Atlas:

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Area of national forests in the United States, exclusive of Alaska and Porto Rico, burned over from 1904 to 1907, inclusive.

[Statistics from Forest Atlas and Boundaries Record.]

Calendar year.	Area of forests on December 31.	Total area burned over.	Percentage of forest area burned.	Area of merchantable forest burned.	Percentage of entire forest area represented by merchantable forest burned.	Value of timber destroyed.
	Acres.	*Acres.*		*Acres.*		
1904	58,052,054	388,872	0.66	.....	.....	.....
1905	92,735,625	279,592	.31	.....	.....	$101,282
1906	122,178,541	115,416	.094	52,374	0.043	76,183
1907	149,869,614	212,850	.14	29,365	.02	31,590

Fires in the Rocky Mountain region in 1902.

Reserve.	Total area burned over.	Timber destroyed.	
		Amount.	Value.
Colorado:	*Acres.*	*Board feet.*	
Battlement Mesa, 807,560 acres	400	15,000	$50
Pikes Peak, 184,320 acres	(a)	.....	.....
South Platte, 683,520 acres	3,033	399,000	1,251
White River, 970,880 acres	700	120,000	650
Idaho:			
Bitter Root, 3,398,400 acres	330	20,000	20
Priest River, 645,120 acres	(b)	.....	.....
Montana:			
Bitter Root, 691,200 acres	1,181	575,000	430
Gallatin, 40,320 acres	.....	.....	.....
Highwood Mountains	.....	.....	.....
Lewis and Clark (N.) 1,428,480 acres	445	175,000	75
Lewis and Clark (S.) 3,242,240 acres	432	2,049,000	3,098
Little Belt Mountains, 45,080 acres	.....	.....	.....
Madison, 736,000 acres	.....	.....	.....
Wyoming:			
Big Horn, 1,216,960 acres	101	.....	.....
Medicine Bow, 420,584 acres	56,700	20,100,000	20,100
Yellowstone, 7,810,600 acres	32,000	991,500,000	991,500
Total	95,322	1,014,953,000	1,017,174

a No damage. b Not estimated.

Fires in the Rocky Mountain region in 1903.

Reserve.	Total area burned over.	Timber destroyed.	
		Amount.	Value.
Colorado:	*Acres.*	*Board feet.*	
Battlement Mesa, 807,560 acres	(a)	.....	.....
Pikes Peak, 184,320 acres	60	45,000	$60
South Platte, 683,520 acres	(a)	.....	.....
White River, 970,880 acres	(a)	.....	.....
Idaho:			
Bitter Root, 3,398,400 acres	814	150,000	4,875
Priest River, 645,120 acres	2½	15,000	10
Montana:			
Bitter Root, 691,200 acres	52	45,000	55
Gallatin, 40,320 acres	(a)	.....	.....
Lewis and Clark (N.), 1,428,480 acres	166	210,000 b 3,800	315
Lewis and Clark (S.), 3,242,240 acres	679	15,000	15
Little Belt Mountains, 45,080 acres	175	10,000	10
Madison, 736,000 acres	(a)	.....	.....
Wyoming:			
Big Horn, 1,216,960 acres	(a)	.....	.....
Yellowstone, 7,810,600 acres	111	30,000	202
Total	2,059½	520,000	5,542
		b 3,800	

a No damage. b Cords.

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Fires in the Rocky Mountain region in 1904.

Reserve.	Total area burned over.	Timber destroyed.	
		Amount.	Value.
Colorado:	*Acres.*	*Board feet.*	
Battlement Mesa, 807,560 acres	(a)		
Pikes Peak, 184,320 acres	(a)		
South Platte, 683,520 acres		3,000	$13
White River, 970,880 acres	(a)		
Idaho:			
Bitter Root, 3,398,400 acres	3,560	3,000,000	4,800
Priest River, 645,120 acres	1,000	950,000	1,950
Montana:			
Bitter Root, 691,200 acres	15,461	895,000 / b 123,760	1,000
Gallatin, 40,320 acres	(a)		
Highwood Mountains	630		
Lewis and Clark (N.), 1,428,480 acres	11,874	25,000,000	25,000
Lewis and Clark (S.), 3,242,240 acres	362	100,000	100
Little Belt Mountains, 45,080 acres	(c)		
Madison, 736,000 acres	(a)		
Wyoming:			
Big Horn, 1,216,960 acres	302	250,000	1,000
Medicine Bow, 420,584 acres	(c)		
Yellowstone, 7,810,600 acres	2,511	1,530,000	1,064
Total	35,700	31,728,000	34,927
		b 123,760	

a No fires. b Cords. c No damage.

Fire report for calendar year of 1905.

[Compiled from reports of forest officers.]

Reserve.	Area burned.	Timber destroyed.	
		Amount.	Value.
	Acres.	*Board feet.*	
Alexander Archipelago	8,104	192,000	$10
Ashland	1		
Baker City	7	1,000	1
Bitter Root (Mont.)	2,647	285,000	275
Bitter Root (Idaho)	8,903	6,192,000	2,630
Black Hills	330		
Bull Run	1,245		
Cascade (N.)	2,620	306,000	785
Cascade (S.)	5,707	932,000	135
Chiricahua	2		
Cochetopa	460	202,000	202
Diamond Mountains	20,440	5,200,000	1,830
Gila	9,300	565,000	790
Gunnison	51		
Henrys Lake	600	3,000	6
Holy Cross	2,500	1,000,000	2,000
Klamath	9,584	3,280,000	1,760
Lake Tahoe	2		
Lassen Peak	3,140	245,000	85
Leadville	690		
Lewis and Clark (N.)	8,508	18,952,000	4,733
Lewis and Clark (S.)	25,609	42,893,000	10,540
Little Belt	310		
Madison	855	4,440,000	4,440
Medicine Bow	4,560	3,762,000	5,643
Minnesota	6,800		
Modoc	30	30,000	30
Mount Graham	43	10,000	19
Mount Rainier	110	1,064,000	518
Payette	2,300	725,000	912
Pecos River	610	20,000	40
Pikes Peak	763	210,000	85
Plumas	3,500	1,890,000	1,154
Prescott	5		
Priest River	11,069	23,360,000	27,320
Salt Lake	80	5,000	10

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Fire report for calendar year of 1905—Continued.

Reserve.	Area burned.	Timber destroyed.	
		Amount.	Value.
	Acres.	*Board feet.*	
San Bernardino	3,972	90,000	$270
San Francisco Mountains	79	25,000	75
San Gabriel	25	1,000	1
San Isabel	11	3,000	3
San Jacinto	140	125,000	125
Santa Barbara	8,019	.....	.....
Santa Rita	9,460	50,000	50
Sawtooth	19,081	5,500,000	8,250
Sierra (N.)	79,083	5,780,000	6,333
Sierra (S.)	9,659	930,000	1,111
Stanislaus	2	.....	.....
Trinity	3,842	16,465,000	10,864
Uinta	300	254,000	744
Warner Mountains	19	25,000	38
Washington (E.)	756	978,000	978
Washington (W.)	4	4,000	3
Weiser	2,145	4,400,000	4,350
Wenaha	1,420	2,130,000	2,115
White River	10	.....	.....
Wichita	17	.....	.....
Yellowstone (Abs.)	1	2,000	3
Yellowstone (W. R.)	2	11,000	11
Total	279 592	152,557,000	101,282

National forest fire statistics for 1906.

[Compiled from supervisors' annual fire reports by E. A. Zeigler; reports cover forests with an area of 97,000,000 acres.]

1. Total area burned over, 115,416 acres, twelve one-hundredths of 1 per cent of 97,000,000 acres reporting.
2. Merchantable area burned over, 52,374 acres.
3. Amount of timber destroyed, 101,970,000 board feet, three one-hundredths of 1 per cent of estimated stand on forests (350,000,000,000 feet).
4. Value of timber destroyed, $76,183.
7. Cause of fires:

	Number.
Railroad locomotives	303
Campers	292
Lightning	261
Incendiary	24
Clearing and brush burning	15
Hunters	13
Herders	7
Indians	5
Miscellaneous	17
Unknown	196
Total	1,133

1907.

Reserve.	Total area burned over.	Timber destroyed.	
		Amount.	Value.
Arizona:	*Acres.*	*Board feet.*	
Baboquivari	(a)	.....	.....
Black Mesa (N.)	556	98,000	$86
Black Mesa (S.)	(a)	.....	.....
Chiricahua	11,500	1,150,000	920
Dragoon	(a)	.....	.....

a No fires.

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1907—Continued.

Reserve.	Total area burned over.	Timber destroyed.	
		Amount.	Value.
Arizona—Continued.	*Acres.*	*Board feet.*	
Grand Canyon (N.)			
Grand Canyon (S.)			
Huachuca		432,000	$800
Mount Graham	350	5,000	16
Pinal Mountains	8		
Prescott	23	3,000	1
San Francisco Mountains	1,149	68,000	157
Santa Catalina	2		
Santa Rita	(a)		
Tonto	30	15,000	15
Tumacacori	(a)		
Total	13,618	1,771,000	1,995
California:			
Diamond Mountains	7	5,000	10
Inyo	(a)		
Klamath	265	108,800	79
Lassen Peak	6	500	10
Modoc	(a)		
Monterey	42		
Pinnacles	(a)		
Plumas	221	252,000	195
San Bernardino	1,047	20,000	30
San Gabriel	420	53,000	64
San Jacinto (see Trabuco Canyon)			
San Luis Obispo	26,177		
Santa Barbara	1,832	75,000	150
Shasta	37	82,600	94
Sierra (N.)	5,000	164,000	147
Sierra (S.)	8,941	2,000,000	5,870
Sierra (E.)	(a)		
Stanislaus	3,763	1,200,000	1,637
Stony Creek	1,154	75,000	300
Tahoe	381	15,000	15
Trabuco Canyon (unclassified 49)	25,000		
Trinity	767	57,000	
Warner Mountains	(a)		
Total	75,060	4,101,900	8,601
Colorado:			
Battlement Mesa	(a)		
Cochetopa			
Fruita	(a)		
Gunnison	23		
Holy Cross			
La Sal. (See Utah)			
Las Animas	5	1,500	6a
Leadville			
Medicine Bow	7	9,000	18
Montezuma	625		
Ouray	(a)		
Park Range			
Pikes Peak	627	82,000a	165
San Isabel			
San Juan			
Uncompahgre	75	10,000	20
Wet Mountains	6	6,500	16
White River			
Total	1,368	109,000	225
Idaho:			
Bear River. (See Utah)			
Bitter Root	460	123,000	145
Bitter Root (Div. 10)			
Big Hole. (See Montana)			
Caribou	(a)		
Cabinet. (See Montana)			
Cassia	(a)		
Coeur d'Alene and Palouse	1,676	1,215,000	3,084
Henrys Lake	1,730	2,000a	7
Kootenai. (See Montana)			
Lemhi (N.)	3		
Lemhi (S.)			
Palouse (included in Coeur d'Alene)			
Payette	303	1,810,600	2,713

a No fires.

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1907—Continued.

Reserve.	Total area burned over.	Timber destroyed.	
		Amount.	Value.
Idaho—Continued.	*Acres.*	*Board feet.*	
Port Neuf		1,000	$3
Pocatello		1,000	3
Priest River. (See Washington)			
Raft River	(a)		
Salmon River	(a)		
Sawtooth	450	552,000	675
Weiser	7	7,000	7
Yellowstone		1,000	2
Total	4,629	3,712,700	6,638
Kansas:			
Garden City	38,400		
Total	38,400		
Montana:			
Big Belt			
Big Hole (Anac. Div.)	(a)		
Big Hole (N.)			
Big Hole (S.)	(a)		
Bitter Root	6		
Cabinet (N.)		600	1
Cabinet (S.)	120	55,000	112
Crazy Mountains			
Elkhorn			
Ekalaka			
Gallatin			
Helena			
Hell Gate (E.)	(a)		
Hell Gate (W.). (See Bitter Root, Mont.)			
Highwood Mountains	(a)		
Kootenai			
Lewis and Clark (N.)	23	5,000	5
Lewis and Clark (S.)	28	43,000	16
Little Belt		700	2
Lolo	132	100,000	125
Long Pine			
Little Rockies			
Madison	(a)		
Missoula			
Otter	1	100	3
Pryor Mountains	(a)		
Snowy Mountains	(a)		
Yellowstone (Shos.)			
Yellowstone (Abs.)	40		
Total	350	204,400	263
Nebraska:			
Dismal River	51,200		
Niobrara	(a)		
North Platte	(a)		
Total	51,200		
Nevada:			
Charleston	5	3,000	6
Independence	(a)		
Monitor	(a)		
Ruby Mountains	(a)		
Tahoe. (See California.)			
Tolyabe			
Toquima	5		
Total	10	3,000	6
New Mexico:			
Big Burros	5		
Gallinas			
Gila (N.)			
Gila (S.)	6,014	90,000	305
Guadalupe	100	100,000	50
Jemez	3	7,000	13
Lincoln	351	500	1
Las Animas			
Magdalena	5	1,000	2
Manzano	10		

a No fires.

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1907—Continued.

Reserve.	Total area burned over.	Timber destroyed.	
		Amount.	Value.
New Mexico—Continued.	*Acres.*	*Board feet.*	
Mount Taylor			
Pecos River	6		
Peloncillo	2,000		
Sacramento	45	6,000	$3
San Mateo			
Taos			
Total	8,539	204,500	374
Oklahoma:			
Wichita	13,840		58
Total	13,840		58
Oregon:			
Ashland	60	15,000	30
Blue Mountains (W.)	181	62,000	109
Blue Mountains (E.)	6	10,000	15
Bull Run	(a)		
Cascade (N.)	213	105,000	108
Cascade (S.)	662	200,000	188
Coquille			
Fremont	220	28,000	33
Goose Lake	125	14,000	180
Heppner	(a)		
Imnaha	12	13,000	20
Siskiyou	113	160,000	320
Tillamook	(a)		
Umpqua	(a)		
Wenaha. (See Washington.)			
Total	1,592	607,000	1,002
South Dakota:			
Black Hills	1,742	237,700	735
Cave Hills	(a)		
Short Pine	(a)		
Slim Buttes	(a)		
Total	1,742	237,700	735
Utah:			
Aquarius	(a)		
Bear River		2,000	7
Beaver	(a)		
Dixie	(a)		
Fillmore			
Fish Lake	(a)		
Glenwood	(a)		
Grantsville	(a)		
La Sal	(a)		
Manti	(a)		
Monticello	(a)		
Payson	(a)		
Raft River. (See Idaho)	(a)		
Salt Lake	28		
Sevier	(a)		
Uinta	(a)		
Vernon	(a)		
Wasatch	(a)		
Total	28	2,000	7
Washington:			
Colville	(a)		
Olympic		15,002,000	7,500
Priest River	2	7,500	7
Rainier	1,840	2,705,000	2,735
Washington (Wenatchee)	107	1,101,000	358
Washington (W)	64	217,000	437
Washington (Chelan)	82	7,000	14
Wenaha			
Total	2,095	19,039,500	11,051

a No fires.

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1907—Continued.

Reserve.	Total area burned over.	Timber destroyed.	
		Amount.	Value.
Wyoming:	*Acres.*	*Board feet.*	
Big Horn	360	1,000,000	$600
Bear Lodge			
Black Hills. (See South Dakota)			
Caribou. (See Idaho)			
Crow Creek	(a)		
Medicine Bow	5	7,600	14
Sierra Madre	1		
Uinta. (See Utah)			
Yellowstone (Teton)	9	18,600	16
Yellowstone (W. R.)	4	1,200	2
Total	379	1,027,400	632
Alaska:			
Afognak	(a)		
Alexander Archipelago	(a)		
Chugach	(a)		
Tongass	(a)		
Total			
Porto Rico:			
Luquillo			
Total			
Grand total	212,850	31,026,100	31,590

[a] No fires.

Final fire statistics for 1907 for national forests (area approximately 150,000,000 acres).

[Compiled from supervisors' annual fire reports by E. A. Ziegler.]

1. Total area burned over, 212,850 [a] acres, or 0.14 per cent of 150,000,000 acres reporting.
2. Timbered area burned over, 29,365 [b] acres, 0.0002, or less than 0.007 per cent of the 450,000,000,000 feet board measure, estimated stand, on this area.
3. Amount of timber destroyed, 31,026,000 board feet.
4. Value of timber destroyed, $31,590.
5. Cost of fire fighting (exclusive of forest officers' salaries):

Labor	$4,259
Supplies	718
Total	4,977

6. Total number of fires reported:

Class A	845
Class B	280
Class C	181
Unclassified	49
Total	1,355

7. Causes of fires:

Campers	346
Railroad locomotives	273
Lightning	176

[a] Large area burned over due to three large grass fires on Dismal River (Nebr.) national forest, 51,200 acres; Garden City (Kans.) national forest, 38,400 acres; Wichita (Okla.) national forest, 13,840 acres; total, 103,440 acres.

[b] Includes area of 11,500 acres in Chiricahua national forest, Arizona, reported as timber land, but only 100 board feet per acre were destroyed.

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7. Causes of fires—Continued.

Donkey engines	65
Clearing land	34
Incendiary	19
Hunters	9
Herders	6
Miscellaneous	60
Unknown or not reported	367
Total	1,358

The Forest Service may justly pride itself upon this showing. The amount of hardship and self-sacrifice undergone by forest officers in order to achieve these results will never be known. The point is that rangers are stationed at convenient intervals throughout the entire forest area; that by their enforcement of the laws and regulations fires are for the most part prevented, but that when fires do occur they are discovered promptly and the necessary steps taken to extinguish them. Rangers are authorized to hire help and fight fire and to purchase necessary provisions. Rangers in adjoining districts and supervisors in adjoining forests cooperate with each other to prevent and control fire, and no effort is spared to prevent the destruction of the forest from this cause. The results already accomplished have clearly demonstrated the fact that destruction of forest property by fire may be almost entirely prevented by the adoption of a suitable system of patrol.

Probably the best example of cooperation betweeen the Federal Government, the State, and the counties in the prevention and control of forest fires occurs in southern California. Under the terms of the state forest law enacted in 1905 the state forester is authorized to maintain a fire patrol in times and localities of particular fire danger. Firewardens are appointed by the state forester, but their salaries and the cost of patrol must be met by the counties in which the patrol is maintained. The greatest danger from fire to the national forests in southern California is from the foothill region along the west boundary, outside the present limits of the forests. In the past these areas have in general been unprotected and great damage from fire has resulted, not only to the areas outside the forests, but to the forests themselves, from fires originating on the outside and burning across the forest boundary. During the past two years, however, a plan has been adopted for the cooperative patrol of a considerable portion of these foothill regions. The plan has been for the Forest Service and the county to provide an equal number of men for this patrol during the four months of greatest fire danger. The firewardens to be paid by the counties are appointed by the state forester. Under the law these appointments may be made, where required by public interests, whether the county concurs or not. In a number of cases the initiative has been taken by the state forester in this way with excellent results. The adoption of this plan has brought about a notable decrease in the number and severity of fires in the foothill region of southern California. Much also has been accomplished in the way of enforcing state fire laws by the general appointment of forest rangers as state firewardens.

Until the past year but little had been accomplished by the Federal Government in the way of cooperation with railroad companies for the prevention of fires on the national forests. That railroad loco-

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motives have been one of the greatest menaces to the forest is unquestionable. That this is true has for the most part been due to two facts: (1) The absence or defective condition of spark arresters; and (2) the failure of the companies to take proper precautions against the spread of fire through the clearing of rights of way and the issuance to employees of proper instructions with regard to the control of such fires as are set by locomotives.

The first deficiency is gradually being remedied through the enforcement of state laws. With regard to the second, practically no steps have been taken outside the national forests, and there only during the past year, after the initiative had been taken by the Forest Service.

At the end of the calendar year 1907, 32 of the national forests in the United States were traversed by coal or wood-burning locomotives through timbered areas in which the railroad rights of way were in such a condition that effective measures were necessary for the protection of the forests from fire. To meet this need the matter was systematically taken up by the Forest Service and an attempt made to secure cooperative agreements with each of the roads operating in the 32 forests mentioned. Field examinations of the rights of way have been made by forest officers, and these reports have formed the basis of action. The details of cooperative agreements are being discussed with a number of railroads. Where cooperation can not be secured it is the policy of the service to sue the railroads for civil damages in every case where damage to the national forest occurs from fire due to the negligence or disobedience of law on the part of any railroad company.

The principal features of the proposed cooperative agreement are as follows:

1. The railroad company agrees to cut and remove all live and dead timber from a strip 250 feet in width on each side of the roadbed on all vacant government land and all lands owned by the company which are crossed by the roadbed within the exterior boundaries of the national forest, the work of clearing this strip to commence not later than a specified date and to be continued, until completed, with reasonable diligence.

2. The railroad company further agrees to clear such strips of all young growth, brush, and other inflammable material, and at all times during the life of the agreement to keep such strips clear of all inflammable material. The cutting of the timber and the clearing of the strips to be done at all times under the direction and to the satisfaction of the supervisor of the national forest in question.

3. The forester authorizes and permits the railroad company to enter upon such portions of said strips as lie upon vacant government land within the national forest, and to remove all live and dead timber and to appropriate the same without charge for the use or benefit of the railroad company.

4. The railroad company permits the forester to attach such telephone lines as may be needed for the proper protection of the national forest to telegraph or telephone poles of the railroad company along the right of way within or near the boundaries of the national forest, such attachments to be made in accordance with the instructions of the railroad company.

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5. The railroad company agrees to adopt a system of notifying the forest officers of any fires discovered by train crews or other employees of the railroad company by warning whistles and by telegraph or telephone communication, such system to be approved by the officer in charge of the forest.

6. The railroad company agrees to furnish at all times at the request of any authorized forest officer a sufficient number of men to assist in fighting fire on or near the right of way, together with necessary tools and the subsistence required while so employed.

7. The forester further agrees to patrol the right of way of said railroad company, and so far as possible to aid in extinguishing fires on or near the right of way.

8. The forester further agrees to supervise the cutting of the timber and clearing of the strips before mentioned, provided that proper and necessary assistance is furnished by the railroad company.

9. The forester further agrees to construct and maintain sufficient telephone lines and to supply at proper points tools and other necessary equipment, sufficient for the effective fighting of fires on or near the right of way.

A good example of actual cooperation on the part of a railroad company occurred during the past summer. The Chicago, Milwaukee and St. Paul Railway Company is constructing a transcontinental railroad through the Cœur d'Alene National Forest, Idaho. Their right of way within the forest is 28 miles in length. Several thousand foreigners are employed upon this work, and during the season the danger from fire along the right of way was very great. An understanding was reached with this company this summer through which it cooperated with the Forest Service by establishing a fire-patrol force of 80 men along the right of way. These men were under the control of four civil engineers, who, before the fire season, had been engaged in construction work on the railroad. It was provided that these men, although in the pay of the railroad company, should be subject to the orders of the forest rangers in that district. As may be expected, a large number of forest fires originated from stragglers from the construction camps, and probably in some cases through the direct carelessness of the contractors and others engaged in construction work on the railroad. These fires were in every case attacked by the patrol force of the railroad and the rangers and were controlled and extinguished before any great damage was done. Had officers of this forest not been successful in securing the cooperation of the railroad company in this region it is probable that the extensive virgin stand of white-pine timber through which the railroad passes would have been completely destroyed.

(*b*) Results Accomplished on Military Reservations, National Parks, and Indian Reservations.

On the military reservations there is very little destruction of timber by fire. The reservations are for the most part small and the proportion of commercial forest low. It is estimated that on all the military reservations there are but 72,964 acres of commercial forest. The estimated total stand of timber is 307,063,000 feet board measure. The presence of troops on or near each reservation makes it possible to extinguish promptly any fire that may occur. In

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some cases patrol is maintained to guard against forest fires. The timbered portion of the Fort Grant Military Reservation, Ariz., has been included in the Crook National Forest, and protection from fire is secured through the patrol maintained by the Forest Service. The same action has been taken with regard to the Fort D. A. Russell Wood and Timber Reserve, Wyo., now a part of the Cheyenne National Forest. The War Department reserves the right to make use of these areas for military purposes, but the grazing and timber and other business and the protection of these areas from fire are conducted by the Forest Service exactly the same as on other national forest land.

The efficiency of the methods adopted by the War Department for the protection of military reservations from damage by forest fires is shown by the following table. Only such reservations are listed as are reported to contain merchantable timber. The figures are from statements made by the respective officers in charge:

Name of reservation.	Area of reservation.	Area burned in 1907.	Method of prevention and control.
Arizona:	*Acres.*		
Fort Grant	42,000	None	Forest Service cooperation.
Fort Huachuca	44,800	.....do	Use of troops.
Florida:			
Fort Barrancas	2,700	.....do	No steps necessary.
Cedar Keys	211	.....do	Do.
St. Johns Bluff	117	.....do	Do.
Georgia and Tennessee:			
Chickamauga and Chattanooga	6,362	.....do	None.
Georgia:			
Fort McPherson Rifle Range	1,271	.....do	Do.
Point Peter	1,100	.....do	Do.
Illinois:			
Rock Island Arsenal	1,000	.....do	Fire service.
Indiana:			
Fort Benjamin Harrison	1,997	.....do	Daily observations.
Kansas:			
Fort Leavenworth	6,970	1,000 acres ($500)	Forester, range riders, daily patrol.
Maine:			
Fort Knox	124	None	Patrol in dry season.
Fort Levett	125	.....do	Troops available.
Montana:			
Fort Missoula Wood and Timber Reservation.	1,577	.....do	Occasional patrol from post 6 miles distant.
Fort Assinniboine	168,610	.....do	Troops available.
New Mexico:			
Fort Bayard	13,760	.....do	Judicious grazing.
New York:			
Fort Wadsworth	230	.....do	Fire department.
West Point	2,556	.....do	
North Carolina:			
Fort Caswell	2,325	.....do	None.
Oregon:			
Fort Stevens	1,250	.....do	Supervision of garrison.
South Dakota:			
Fort Meade	7,700	150 acres ($50)	Guard duty.
Virginia:			
Fort Hunt	197	None	Burning grass in fall.
Washington:			
Three Tree Point	640	.....do	None.
Hoods Head	43	.....do	Do.
Gig Harbor	78	.....do	Do.
Port Defiance	638	.....do	Guard by employees.
Nee-ah Harbor—			
West side	381	.....do	None.
East side	398	.....do	Do.
Washington Harbor—			
West side	475	.....do	Guard by lessee.
East side	424	.....do	None.
Challam Point	548	.....do	Do.
Hope Island	200	.....do	Guard by lessee.
Northern part of Whidby Island.	606	.....do	None.

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Name of reservation.	Area of reservation.	Area burned in 1907.	Method of prevention and control.
Washington—Continued.			
Deception Pass—	*Acres.*		
South side	630	None	None.
North side	550	do	Do.
Shaw Island	1,103	do	Guard by residents.
Lopez Island	1,311	do	Do.
San Juan Island	1,124	do	Do.
Fort Townsend	615	do	Guard by caretaker.
Tala Point	162	do	None.
Foulweather Point	485	do	Do.
Double Bluff	626	250 acres ($3,000)	Do.
Vashon Island	487	None	Do.
Protection Island (land opposite).	354	do	Do.
Fort George Wright	1,023	do	Patrol by soldiers.
Fort Ward	230	do	
Fort Flagler	905	do	Cleared strip.
Wyoming:			
Fort D. A. Russell Target and Maneuver Reservation.	36,800	do	Notices, Forest Service patrol.

On the national parks protection from fire is as complete as on the military reservations, according to the reports of the respective superintendents. The parks are in general much larger than reservations and contain a much greater area of merchantable forest. It is estimated that in all the national parks there are 2,540,000 acres of merchantable forest. The total stand of timber on this area is estimated at 10,717,000,000 feet b. m. Where danger from fire exists a regular patrol is maintained, and a sufficient body of troops is available to promptly extinguish any fire that may occur.

The following table shows results obtained along this line during 1907 on such national parks as are reported to contain merchantable timber. The figures are from statements submitted by the respective superintendents:

Name of park.	Area of park.	Area burned in 1907.	Methods of prevention and control.
California:	*Acres.*		
Yosemite	967,680	None	Guard by cavalry.
Sequoia and General Grant	172,165	do	Patrol, warning notices, road, trail, telephone, fire lines, tool stations.
Oregon:			
Crater Lake	159,360	do	Patrol.
Pennsylvania:			
Gettysburg	2,047	do	Guards, workmen, and tenants.
Tennessee:			
Shiloh	3,325	do	Annual ground fires.
Washington:			
Mount Rainier	207,360	do	Regular fire patrol (3 men during July, August, and September), 2 tool stations, warning notices.
Wyoming:			
Yellowstone	2,142,000	do	Daily patrol, troops and rangers, enforcement of park regulations, fire-fighting tools constantly accessible.

No statistics are available as to damage by forest fires on the Indian reservations. It is, however, known that these reservations have received immense damage from year to year, and that but little effort has been made to prevent the indefinite recurrence of such damage. Fires occurring near the agencies have in many cases been extinguished. No provision has, however, been made by Congress for a systematic patrol. Superintendents of Indian reservations

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have neither the authority nor the funds to employ men for fire fighting, and it is very difficult to get the Indians to voluntarily perform work of this kind. Under such circumstances, fires will inevitably occur in the future, as they have in the past, in the more remote and inaccessible regions. These fires usually owe their origin to carelessness, malice, or natural causes, and, as a rule, continue unchecked until they either burn out or are extinguished by rain.

Indian reservations are located in 14 States and Territories. It is estimated that there are in all the reservations 10,541,900 acres of merchantable forest, carrying a stand of 34,089,000,000 feet b. m. of timber. That adequate steps should be taken for the safeguarding and perpetuation of this vast property can not now be questioned. Undoubtedly a comprehensive system of protection and management should be adopted, based upon that now in use upon the national forests. A beginning along this line has already been accomplished by the cooperation of the Forest Service with the Indian Office during the past summer. On the Klamath and Coeur d'Alene Indian reservations the plan is in actual operation and will be carried on indefinitely so long as funds are available. Its extension to other forests is merely a matter of time.

The total area of the Klamath Indian Reservation, Oreg., is about 1,100,000 acres; of this, it is estimated that 700,000 acres are timbered. The question of cooperative protection arose during the summer of 1908, the Indian agent being unable to cope successfully with the several large fires which were burning on the reservation. After some correspondence, an understanding with the Indian Office was reached whereby 5 men were placed on patrol on the reservation under the direction of the supervisor of the Crater National Forest, whose headquarters are at Medford, Oreg. A fund of $2,500 was made available in the Indian Office to cover the salaries of these men during the fire season. An additional sum of $1,000 was made available to be expended by the Indian agent for fighting fire. Owing to the fact that several fires had gained great headway before steps were taken toward their extinguishment, the entire balance of the fire season was spent in fire fighting, with the result that the fires were brought under control and a vast amount of timber saved from destruction.

A similar plan was put into effect during the past summer on the Coeur d'Alene Indian Reservation in northern Idaho. This action was made necessary by the fact that two lines of railroad cross the reservation, thus endangering not only the timber on the Indian land, but also on the adjacent Coeur d'Alene National Forest. As in the case of the Klamath Reservation, a plan was adopted whereby three forest guards were placed on patrol under the direction of the supervisor of the Coeur d'Alene National Forest. Just as this plan was approved, occasion arose to test it through a severe fire on the Indian reservation.

On August 5 and 6 a forest ranger who was patrolling a district in the Coeur d'Alene National Forest some distance south of the Coeur d'Alene Indian Reservation, noticed considerable smoke drifting in from the country to the north of the national forest. On the 7th the smoke became so dense that the ranger left his district and traveled on horseback into the Indian reservation, where he discovered a large forest fire burning in valuable timber on the reservation. The reser-

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vation authorities at this time had no system of fire protection on their lands and nothing was being done to check the fire. The flames had a front of about 5 miles and were traveling rapidly before a strong wind through a dense forest of white and yellow pine, red fir, hemlock, and tamarack. Nearly a half-billion feet of merchantable timber was in imminent danger. Officers of this forest at that time had no authority to fight fires on the Indian reservation. The ranger, however, rightly judged that some action could be taken to save the government's property, and rode to St. Maries, the nearest telephone office. Upon telephoning to the supervisor of the national forest at Wallace, he was instructed to take in a crew of 20 men to the fire and return to St. Maries for instructions.

Meanwhile the forester was wired from Wallace that forest rangers were fighting fires on the Indian reservations, and instructions were requested. On August 8 the forester replied by wire, instructing the officers of this forest to extinguish the fire and to keep him informed by telegraph.

About 40 more men were accordingly gathered and dispatched to the fire, which was located in an inaccessible region. In order to get in camps and supplies for this large crew, it was necessary to construct several miles of trail, and the entire force was put on the fire within twenty-four hours after receiving final instructions from the supervisor at Wallace, and within another twenty-four hours the fire was practically under control.

The burned area was large and was covered with smoldering logs, stubs, and remnants of the fire. It was not possible to extinguish the fire within the burned area, and the efforts of the men were directed toward hastily constructing a trail or fire line around it and fighting the fire back on this line. For several days strong winds prevailed, and it was only by the greatest effort that the men were able to hold the fire within the burned limits. In some instances the fire leaped the barriers and more fire lines had to be constructed around newly burned areas.

The weather continued exceedingly dry, and it was nearly four weeks before it was possible to withdraw all the men. As this district was remote from the supervisor's office at Wallace, and the supervisor himself was constantly engaged in controlling the many fires on the national forest, it was difficult to provide means for promptly paying the men. Most of them were hastily secured from many sources and were penniless. In order to retain them it became necessary to devise means for promptly paying them for their services. Firewarden Ross of the State and Lumberman's Protective Association, who was stationed at St. Maries, volunteered to reimburse the men through orders drawn on the association, the account of the association to be, of course, later submitted to the Government for payment.

The cost of fighting this fire was approximately $4,500, of which nearly one-fourth was expended in supplies and equipment, the remainder being paid in wages.

Probably one-half billion feet of timber, valued at $2,000,000, were saved by controlling this fire. The great cost of fighting this fire is in contrast to those extinguished on the Coeur d'Alene National Forest, the average cost of which amounted to about $400 per fire. The difference is due entirely to the fact that there is on the Coeur

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d'Alene National Forest a system of fire patrol and protection, and fires in the forest were discovered and extinguished before they gained much headway. It is probable that at a cost not exceeding $2,000 a system of fire patrol could have been maintained on the Indian reservation which would have prevented the great damage done by this fire.

(c) RESULTS ACCOMPLISHED ON THE PUBLIC DOMAIN.

Of the unappropriated public domain outside of Alaska it is estimated that 4,448,400 acres are forest land, bearing a stand of 13,838,000,000 feet b. m. of timber. This area is so widely scattered, and is passing out of the hands of the Government at such a rapid rate, that its protection and administration would be impracticable even were there any provision for such a course. As a matter of fact, there are neither funds nor men available for this purpose, and absolutely no steps have been or are being taken to prevent the destruction by fire of timber on the public domain. In the States of Oregon, Washington, Idaho, Montana, Wyoming, and Colorado further additions to the National Forests are prohibited by law, except by act of Congress. Important bodies of commercial forest in the other States have either been included in National Forests, or are under temporary withdrawal, or else have been filed upon and are either patented or in process of becoming so. Under these conditions but little action on the part of the Federal Government is practicable along the line of fire protection. In some cases fires on the public domain adjacent to the National Forests are extinguished by forest rangers. This action is taken in every possible case where the National Forest is threatened. Owing, however, to the limited amount of money available for fire protection on the forests, but little protection to lands outside can be given by the Forest Service.

The unappropriated timber lands of the public domain are for the most part either in such small bodies or are situated so remotely from transportation that they offer but little attraction to the individual as an investment. In many cases they consist of isolated and widely scattered tracts of 40 or 80 acres, so that it is impracticable to secure a satisfactory timber and stone claim; in others the amount of timber on a possible claim is so small that it is not worth while to go to the expense of locating and filing; and in many instances the timber is so far distant from possible transportation or utilization that its location is not considered good business policy. It must be realized, also, that only a small percentage of the remaining public domain contains commercial forest, and that great expense and loss of time are involved in determining from the land office records what areas are still unappropriated and in making the necessary field examinations to ascertain which of these areas are timbered. These conditions are for the most part responsible for the fact that any of the timbered portion of the public domain still remains in the hands of the Government.

Not only is the timbered portion of the public domain rapidly passing into private ownership, but the danger from fire to the portion remaining is constantly increasing. The comparatively small isolated tracts are for the most part surrounded by private holdings of timber lands. Some of these lands have already been

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lumbered and others are being held for future cutting. On the lands which have not been lumbered there has until very recently been practically no attempt at fire protection. The lands of the public domain have received the same damage from fire that has been received by lands in private ownership. Where, however, privately owned lands have been lumbered the slash has been left on the ground, forming a fire trap, and the resulting damage from fire to adjacent uncut timber on the public domain has been very great. As lumbering proceeds on private holdings the damage to unreserved government timber lands will constantly increase, until practically all the timber on the public domain is either filed on or destroyed by fire.

(2) RESULTS ACCOMPLISHED BY STATE GOVERNMENTS.

As compared with the urgent need for adequate prevention and control of forest fires but little has been accomplished by state action. Many laws have been passed by the various States, which vary greatly among themselves, and many look well upon the statute books. Laws against the setting of fires are far from uniform, but in practically all cases they would be sufficient were they enforced. The fact is, however, that they are not enforced, and never have been in any State. The machinery for proper enforcement is wanting. If the owner or his agents catches a man setting a fire he can prosecute through the proper office, bring the case into court, and if he can get the jury to convict he can get the offender punished. It is, however, a matter between owner and court, and not one of proper police. This lack of protection has in general worked strongly against the holding of forest lands as a permanent investment. In many parts of the country areas that would otherwise have been held for future cutting or for a second crop have been cut clean because of the fear that if this action were not taken great loss would result from forest fires. Small areas of timber surrounded by cut-over lands have been considered as practically doomed and every effort made to get them lumbered before their destruction by fire.

Usually with the first code adopted by each State came laws (derived like the laws on forest trespass) dealing with the prevention of fires in forest and on prairies. Like the laws on trespass, these earlier efforts are simple, direct, and severe. Thus in Michigan as early as 1846 the law provided a penalty for willfully burning the woods of another amounting to as much as five years in State prison and a fine of $500. Quite early, and in some cases as parts of the first protective act, came provisions making the fighting of forest fires a special duty of the supervisor, the justice of the peace, or the highway commissioner or some other official, giving these officials power to call out the citizens and making it obligatory, under severe penalty upon the citizen, to obey summons and help in the fight against fire. The responsibility of the local authorities was thus clearly recognized at an early date. But there was a penalty prescribed only for the citizen and not for the officer, and so the officer found it to his political interest never to call people out.

Thus these laws (even more than the laws of trespass) remained dead letters. The difficulty of catching the evil doer, the ease of finding excuses in having to clear land, burn brush, cook food on camp

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fire, etc., and thus establishing some reason for the existence of fire; then, also, the matter of accident, the pipe, the cigar and match and torch all allowed in the forest at any time and season; the general permission of any one to travel, camp, hunt, and fish on other people's lands; all these made it practically impossible for the owner or his agent to bring the matter before court and secure conviction. And even if conviction could be had, it could have been of little value, for it is prevention of fire and not merely conviction of the "fire bug" that is wanted. And here, again, State, county, and town did nothing; and with this the sense of individual as well as corporate responsibility disappeared.

After a number of really great calamities, like the fires of 1871, 1881, and 1894 in the Great Lakes region, where hundreds lost their lives, thousands became homeless, and the damage ran well up in the millions, the situation became positively intolerable. The people clamored for action and the legislatures reluctantly enacted a series of laws, all of which were more or less modifications of the old fire-fighting laws already in existence, and collectively perhaps best termed "firewarden" laws. Like the trespass agents and gamewarden laws, they are a makeshift, a duplication and interference in what should and could be the proper administrative body of the state government. The Michigan law, copied and modified from that of New York and Minnesota and again copied by Louisiana, etc., will illustrate this phase of state action. The State had a good, simple, though somewhat incomplete, forest-fire law, with a provision which made it the duty of the supervisor, justice, and road commissioner to call out the people and fight forest fires. Beyond this the State never spent a cent in protecting its second greatest natural resource and its second industry.

After enormous losses and years of agitation, the legislature, in 1903, made the state land commissioner a state forest commissioner (and this in spite of the fact that he already was a member of the state forestry commission), gave him power to appoint a state fire-warden. This man, with a salary of $500 per year, had authority over the supervisors, who were thus once more legislated into the fire-warden job. The earlier law was repeated in its main features, but the people were to receive pay for fighting fires, and the sum total spent in any one town should not exceed $50 in any one year, so that if $49 were once spent the people had to be sent home because there was no more money available. The state land commissioner himself in a public meeting declared that the law was not worth the paper it was printed on.

In 1907 the power of the land commissioner was transferred to the state gamewarden, who was made fire and game warden; the idea being, since this office was equipped by law with deputies scattered over the State, that it was a mere police body and thus would do better work. The fact is, however, that the law has fallen far short of accomplishing the desired end. During the past season (1908) fires have raged throughout the northern peninsula of Michigan and throughout the northern portion of southern peninsula. Although every supervisor was by law compelled to fight forest fires, as a rule no steps were taken until some town or especially valuable piece of private property was threatened with flames. In many cases action of this kind was taken too late, and as a result, in the State of

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Michigan alone, loss was caused amounting to several million dollars. The same thing has been true in Wisconsin and Minnesota and many other States during the present season. In no State is there as yet an adequate system of protection against forest fires. Some of them have, however, been far more progressive than others and have made good beginnings along this line. The figures already quoted as to fire losses in some of the States, while neither complete nor accurate, are sufficient to demonstrate that even small expenditures of money and effort are well repaid by the results obtained. The difficulty has benn that in every case the expenditures of money and effort have been inadequate to meet the real needs of the situation.

The results of the forest-fire law in New Jersey illustrate to a remarkable degree the great saving brought about by protective measures. The law creating the forest park reservation commission was passed in 1905. A state forester is employed by the commission to superintend the general forest work. In 1906 provision was made for a state forest-fire service, under the direction of a state fire-warden. The essential feature distinguishing the New Jersey plan from that adopted in other States is a paid organization which ignores property lines, covering the whole State and cooperating in every way possible with the owners of woodland, with the railroads, and with everyone having an interest in the suppression of fires. Township wardens receive $20 and district wardens $10 per year in addition to a per diem compensation for the time actually spent in fire fighting. The service now includes 300 firewardens, all of whom are expected to be on the lookout for fires and to summon help to extinguish one the moment it is discovered.

For this purpose they are authorized to require the services of any able-bodied citizen, under a penalty of $10. The expense of fighting fires is borne equally by the townships and State. The report of the state firewarden shows that for the year 1907 the loss from forest fires was less than one-tenth of that of any former year. This betterment in conditions can be traced directly to the activity of the firewardens. An important feature in this connection is the issuing of permits for burning brush. During the entire year no fallows, stumps, logs, brush, dry grass, or fallen timber may be burned in specified townships without the written permission of a firewarden. Such permission is refused where the burning would endanger any forest or woodland. In the past the burning of brush for the clearing of land has been the most fruitful source of forest fires. As a result of the new law, it is significant that but 7 per cent of the forest fires reported in 1907, whose origin is known, started from brush fires, whereas in former years the proposition was usually about one-fourth to one-third. The success of the state forest policy has been reflected in a general rise in the value of forest land. Rough woodland worth less than $1 an acre a few years ago is now held at $5 and more. Undoubtedly a part of this increase has been due to the general rise in land values, but there is no question but that the additional security from loss by fire under the new law has been an important factor in bringing about a realization of the revenue-producing possibilities of forest land.

New York is another good example of a State with fire laws which are progressive as compared with those of the great majority of the States. Even in New York, however, the law is inadequate to meet

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the situation. It is believed that the figures given in the first part of this paper for fire losses in the Adirondack and Catskill counties do not represent even approximately the true loss, to say nothing of the entire State. Much as has already been done, more remains to be accomplished, and unquestionably the facts justify the statement made by Col. W. F. Fox, superintendent of state forests, that without the system of state protection at present in force, fires would have been unchecked and would have resulted in the destruction of the entire forest. The state law provides for the appointment by the forest, fish, and game commissioner of a chief firewarden, to have supervision of town firewardens, visit and instruct them in their duties, and enforce the law as to fire districts in towns, and under the authority of the commissioner commence prosecutions for violations of law, to prevent forest fires. The law provides also for the appointment by the commissioner of a firewarden in every town having lands in the forest preserve, and the optional appointment of a firewarden in every town having lands that would become a part of the forest preserve if acquired by the State. Division of towns into two or more fire districts is provided for, to be guarded by district firewardens appointed by the town firewardens. In towns not included in the forest preserve the supervisor is made firewarden by virtue of his office. Firewardens, district firewardens, and laborers receive pay for time actually employed in fire fighting. All bills are approved by the firewarden and paid by the town in which the fire occurs. When approved by the commissioner one-half the amount is reimbursed the town by the State. During the present year there are 743 town and district firewardens under appointment.

The law provides also that whenever in the judgment of the commissioner it is necessary to protect the forests from fire he shall organize and, as long as necessary, maintain a fire patrol along the lines of railroad in forests in counties containing part of the forest preserve, and at such other places in such counties as the public interest requires, one-half the expense to be borne by the company and one-half by the State.

In order to reduce as much as possible the danger from railroads, each railroad company is required by law, on such part of its road as passes through forest lands or lands subject to fires from any causes, to cut and remove from its right of way along such lands, at least twice a year, all grass, brush, and other inflammable material. Patrol of tracks at the expense of the company is required, as is also the use of efficient spark arresters. Were these laws fully enforced immense good would result. That the desired protection has not yet been secured is shown by the fact that during the present season fires have raged all through the Adirondack and Catskill regions, it being claimed by the state authorities that 90 per cent of the fires have been caused by railroads. The State spent over $100,000 in fighting fire this year, but more than 1½ millions of dollars worth of property has nevertheless been destroyed. What is needed is the inclusion of further immense areas of nonagricultural forest lands in the state preserve, and the adoption of an adequate system of fire patrol at the expense and under the supervision of the State. The action most needed, however, is a law that will compel the adoption of electricity or oil as motive power for railroad locomotives through forest regions. The numerous disastrous fires that have occurred

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during the summer of 1908 have made this a distinct issue in New York, and the question is under investigation by the public service commission. Hearings have already been held, at which were present representatives of the railroad companies, as well as of a number of private and public interests and organizations desirous of securing adequate protection from forest fires.

As an argument in favor of the compulsory adoption of petroleum as fuel, the case is cited of the Raquette Lake Railway, which extends for 19 miles through the state forest from Clearwater to Durant, In granting the charter for this road the legislature stipulated that petroleum must be used for fuel. During the twenty years that this road has been in operation not a single fire has occurred along its right of way. The agitation for the general adoption of petroleum as fuel is met by the railroads with the statement that the Adirondack and Catskill roads are neither strong nor profitable, and that the expense of equipping the locomotives with oil burners would be almost confiscatory. It is contended also that many of the fires attributed to the railroads have in reality been set by the indiscriminate building of small fires for camping and pleasure purposes. The fact that some of the railroads in the Western States are changing from steam to electric power, utilizing local water powers for this purpose, was cited as an argument in favor of similar action in New York. This, however, was met by the contention that it would be impracticable to operate the roads by electricity secured from water power in the Adirondacks, as these water powers are insufficient during the dry season when railroad traffic is heaviest.

Along with New York and New Jersey, the States of Pennsylvania, Minnesota, Wisconsin, Maine, Maryland, Connecticut, Washington, and California are generally regarded as having done most to secure protection from forest fires. There is great variation as to the details of the plans in operation, the idea being generally adhered to, however, of firewardens under State supervision, paid locally, or in part locally and in part by the State. In general the same conditions prevail as have already been described for Michigan and New York with regard to the nonenforcement of laws and inadequacy of measures adopted.

In Maine, the legislature each year makes provision for the expenditure of $20,000, or so much thereof as may be necessary, to be used in fire fighting. In dry years this amount is absolutely inadequate, and the burden falls on the individual owners. In a number of cases fire-lookout stations are erected and equipped by the owners of wild lands, the State paying in each case the salary of the men assigned to the station, the owners bearing all other expenses. These stations are located on mountains commanding views for long distances, and are equipped with telephones and fire-fighting tools. Lookouts are maintained from June to November.

In Connecticut a firewarden system was provided by law in 1905. The state forester is ex officio forest firewarden without additional salary. About 400 wardens are under appointment, and the annual fire damage has been reduced to about one-fourth what it was before the adoption of the fire law.

In Wisconsin the state forester acts also as state firewarden, with power to appoint one or more firewardens in each town. Over 300 of these wardens are now under appointment in the northern part of

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the State. The State has also appointed an inspector, whose duty it is to examine all railroad locomotives in use in the northern part of the State, to see that they carry efficient spark arresters, and that the rights of way of the railroads are kept free from grass, brush, and other inflammable material.

Minnesota is one of the pioneers with regard to forest-fire protection. Supervisors of towns, mayors of cities, and presidents of village councils are ex officio firewardens under the direction of the chief firewarden, who is appointed by the forest commissioner. Five thousand dollars may be expended for fire fighting. Gen. C. C. Andrews, who as chief firewarden has been in charge of this work for many years, reports that the measures adopted have lessened the fire damage very greatly.

The Washington legislature enacted a forest-protection law in 1905. This law provides for the appointment by the governor of a state board of forest commissioners to serve without compensation. This board has power to appoint firewardens in each of the timbered counties of the State. While the measures taken have been effective in preventing fire damage to some extent, yet the number of wardens appointed (22 in 1905 and 23 in 1906) has been insufficient to meet to any degree the real needs of the situation. Outside the National Forests, fires have for the most part occurred on cut-over lands. This has given rise to an attempt to minimize the damage by fires which have occurred during the present season. In making estimates of such loss, however, little attention has been paid to the medium-sized material destroyed and none to the young growth. Almost invariably fires on cut-over lands encroach on virgin timber, and in the heavy forests of the Northwest the loss mounts up with great rapidity. Instead of spending $4,300, as in 1905, and $5,190, as in 1906, the State could well afford to appropriate such amount (between $25,000 and $100,000 annually) as would provide for an efficient patrol and make forest fires a thing of the past. As it is, the work of protection is, as a matter of fact, left to the individual owners to provide for.

In California the forest-fire situation is anything but satisfactory. One-third of the State, or approximately 33,000,000 acres, is in some degree forested, of which 25,000,000 acres are in the national forests. This leaves 8,000,000 acres of forest land for the protection of which the State is properly responsible, in addition to an immense area of chaparral, brush, and grass land, on which there is constant danger from fire during the dry season of the year. The only exception to this is perhaps in the redwood belt of Mendocino, Humboldt, and Del Norte counties, where, on account of the prevalence of summer fogs, fires do practically no damage over an extent of 1,000,000 acres. The greatest damage from fire is in the southern part of the State, along the foothill ranges, outside the National Forests. In the northern part much of the finest timber is in the hands of individuals and private corporations, and is situated outside the National Forests. But little protection from fire is furnished by lumbermen, and still less by the State. The annual loss from forest fires occurring outside the National Forests is upward of half a million dollars, according to the estimate of the state forester. There is great variation from year to year, the estimate for 1890 being upward of ten millions for

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the entire State, according to the report of the state board of forestry for 1889–90.

A voluntary firewarden system is in operation, appointments being made by the state forester. About 700 wardens have been appointed, who are given power under their appointments to arrest for violations of the forest laws, to issue burning permits (without which it is unlawful to set any except camp fires during a dry season), and to compel assistance in fighting fires. Because the State made no appropriation from which firewardens could be paid for their services, the preventive value of the system has not been great. To increase it, many counties have been requested to make appropriations, as allowed under the state law, from which firewardens acting within the county could be paid. This has resulted in the appropriation of money in the following counties to support the number of firewardens indicated:

Santa Cruz.—One firewarden.
Los Angeles.—One firewarden, and funds from which fire fighters are paid for their services.
San Bernardino.—Five hundred dollars from which firewardens are paid for their services.
Riverside.—Five hundred dollars from which firewardens are paid for their services.
Tulare.—Two hundred and fifty dollars for payment of firewardens.
San Diego.—Five hundred dollars for payment of firewardens.
Fresno.—Two regular firewardens and $500 for payment of services rendered by fire fighters.
Kern.—One thousand two hundred and fifty dollars for two regular firewardens and services rendered by fire fighters.
Merced.—One regular firewarden.
Glenn.—One regular firewarden.
Madera.—Two firewardens.
Santa Clara.—One firewarden.

In general, the best results from state efforts and the only ones which have been quite satisfactory have been derived from the action of several of the States in establishing state forests or parks. First in the list come New York, Pennsylvania, and Wisconsin; then the smaller beginnings made in Minnesota, Michigan, Connecticut, Massachusetts, New Jersey, Indiana, etc. The New York state forest preserve comprises 1,599,638 acres; the area of the Pennsylvania state reserve is 761,000 acres; and in Wisconsin 300,000 acres have been set aside as a state reserve, including 20,000 acres donated by the Federal Government. The area of lands reserved for forest purposes in some of the other States is as follows: Michigan, 39,000 acres; Minnesota, 42,800 acres; New Jersey, 9,867 acres; California, 3,800 acres; Indiana, 2,000 acres; Maryland, 1,957 acres; and Connecticut, 1,600 acres. Protection from fire is an important part of the system of management which it is expected will be inaugurated on these lands as rapidly as funds will permit. Judging from the example set by the most progressive states of continental Europe, the segregation, protection, and management of the state forests will ultimately become the principal line of state activity with regard to forest matters in this country. The conditions in Michigan are a good illustration of the desirability of such action on a large scale in States where there are cut-over forest lands not chiefly valuable for agriculture. Michigan owns at the present time about 800,000 acres, most of which has reverted to the State for nonpayment of taxes. These lands are in general not valuable for agricultural purposes.

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They have cost the State millions of dollars in advertising and clerk hire; they have been sold over and over again at purely nominal prices without an investigation as to their value. The lands which the State now owns have been cut over repeatedly; immense areas come up every year for nonpayment of taxes; and still the State spends large sums trying to get rid of them. During the past five years Michigan has sold over 800,000 acres of tax lands at about $1.20 per acre. It is now shown by special examinations that they had timber enough on them to pay the above sum twice over. Thus the State has given away land and timber and young trees to the amount of millions of dollars. Not only that, but the lands thus sold are held by the owners just long enough to cut off the timber; the land then burns over, and the tract again reverts to the State for nonpayment of taxes. Thus the land policy pursued by this State has robbed the State of millions of money and of millions of acres, and directly resulted in the total and repeated devastation of immense areas of land chiefly valuable for the production of timber. Had the State kept its lands, sold them only on application and at fair price, and separated all poor lands as forest reserves, it would have received more money, these reserves would now produce an income instead of causing expense, fires would be done away with, and the State of Michigan would be in a fair way to supply itself again with all forms of timber instead of having to import them, as it now does. What is true of Michigan in this regard is true also of many other States. Where lands do not revert to the State for nonpayment of taxes, a policy of purchase, protection, and reforestation is the only practicable solution of the present unsatisfactory condition.

In addition to this policy, however, which can at the best be carried on but slowly, and which should include only lands not chiefly valuable for agriculture, the States should immediately take radical action to provide an efficient patrol for all forest regions. The many fires which have occurred during the present season in all parts of the United States emphasize this need with greater strength than has been the case in any previous year. In this connection the following quotation from The Minnesota Forester for September, 1908, is of interest as an illustration of conditions in the Northwest:

> On September 1, 1894, the forest fires swept over that portion of the State surrounding Hinckley. They wiped out that town completely, damaged several other towns, burned over 400 people, left over 2,000 others homeless, and destroyed property valued at $25,000,000. Investigations showed that the loss was the result of carelessness in regard to forest fires in their incipiency. It was shown that a reasonable amount of money expended by the State in patrol and other preventive measures would preclude any such disasters in the future.
>
> Under pressure of public opinion and the findings in regard to the cause of the loss the legislature grudgingly appropriated $6,500 for forest protection, $1,500 to be paid to a chief forest firewarden. The legislature seemed to feel that it had met the requirements, but it had totally ignored the "reasonable amount."
>
> Fourteen years later (1908) another fire wipes another town (Chisholm) off the map, damages others, leaves thousands of persons homeless, and destroys $5,000,000 worth of property. Investigation shows that the fire was caused by carelessness and neglect in fighting fire when it was small.
>
> The direct and immediate loss from these two conflagrations was about $30,000,000. The consequent loss of wealth production in the following years would probably amount to more than that, but is ignored in these calculations, because few people look deep enough to see it. The direct losses, then, from these two fires would pay the state appropriation for fire protection, as it now stands, for the next 4,600 years. Is that not rather a low insurance rate,

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especially when it is remembered that these two fires form only a fraction of the total losses to the State? The forestry commissioner has at his disposal about a quarter of a mill an acre for the protection of the land under his care. No business concern in the world would expect to get adequate protection at such ridculously low rates.

An appropriation of half a cent an acre on the 20,000,000 acres of forest land would furnish efficient protection. That would mean an appropriation of $100,000 per year. It sounds like a great deal of money. The losses sustained in the Hinckley and Chisholm fires alone would pay it for 300 years. Considering that 20,000,000 acres are worth only $3 per acre—the value of all the towns in the district ought rightly to be figured in—we have a property worth $60,000,000. One hundred thousand dollars premium on even such a valuation would be less than 1½ mills on the dollar. What kind of insurance can be obtained for less?

It is to be hoped that the disasters in the neighborhood of Chisholm will awaken the state legislature to the ridiculous business methods which they have been using in the administration of their northern forests and impress upon them the necessity of larger appropriations to prevent such disasters in the future. The landowners in the forested districts pay taxes and should get protection; they get nothing else for their taxes and should insist on having the protection.

(3) RESULTS ACCOMPLISHED BY PRIVATE OWNERS.

In reply to questions sent out by the National Conservation Commission to owners of large tracts of forest lands throughout the United States, replies were received from 369 individuals or firms, representing holdings amounting to 13,150,085 acres. Of this area it was reported that 3,917,087 acres are protected from fire. This, however, does not mean that on this area the prevention of forest fires is secured, but that while prevention is secured in some cases, in general an organized attempt is made to extinguish such fires as may occur.

It is estimated that of the 450,000,000 acres of forest land in private ownership in the United States, probably not more than 1 per cent is under an efficient system of fire protection. By an efficient system is meant one in which prevention is the object sought rather than merely control after fires have actually begun. As already stated, for a system of this kind some plan of patrol is essential. A few years ago practically no attention was paid to forest fires by lumbermen and private owners, loss from this source being considered inevitable and pertaining naturally to the business. With the depletion of the timber supply, however, and the rapid rise in stumpage prices, a gradual change has taken place. Individual owners have been more ready to spend money to protect their holdings; cooperation has gradually developed in cases where fire danger is greatest, and in some instances, as in Idaho and in Washington, the movement for concerted action has spread until it has covered the largest timber interests of the respective States, involving even the State and Federal Governments in the general plan. The steps so far taken have been confessedly inadequate, since they have for the most part fallen far short of preventing fire damage. They are, however, moves in the right direction, and the results obtained show conclusively that fire damage can be practically eliminated provided the owners of forest property affected are willing to pay a reasonable amount for the protection. Money spent in this way is the cheapest possible form of insurance and is repaid many times over, not only in the form of the timber saved but in the higher values resulting from greater security from loss.

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The Pocono Protective Fire Association is a good example of what can be accomplished in the way of preventing damage by forest fires through the cooperation of private owners. This association is an organization of forest owners in northeastern Pennsylvania, whose property aggregates upward of 100,000 acres. To stop the fires that have burned over their land every year the association began five years ago by securing the appointment of deputy constables in each of the seven townships in which its members own forest. Under the state law these men have all the powers of firewardens, including authority to call on any citizen to assist in fighting fire. A reward of $100 is offered for information leading to the arrest and conviction of any person starting a fire, or for such information as could be used as evidence against railroad companies. The expenses are met by an annual assessment of 6 mills per acre of land owned by the members. As a result strict enforcement of existing laws has been secured, and damage by forest fires has been practically eliminated on the tract in question.

The experiment conducted on the cut-over land of the McCloud River Lumber Company, in northern California, is a good example of what may be accomplished in the way of fire protection on forest lands in private ownership. This experiment was started in 1905, in accordance with a plan prepared by the Forest Service. The tract had been logged for the seven preceding years, and about 43,000 acres cut over. The amount of combustible débris left on the ground as a result of the lumbering operation was very great. Young growth existed in great quantities and of all sizes up to 18 inches in diameter. The problem was to adopt an adequate system of fire protection in order that the small and medium sized trees might reach merchantable size and at the same time the surrounding timber forest be protected from the menace incident to the proximity of so large an area of cut-over land. In accordance with the plan prescribed, fire lines were constructed at an average cost of $15 per mile. A patrol route was laid out, covered by a mounted patrolman daily for the four months of greatest fire danger—that is, from June to September. Tool stations were located at convenient points and telephone lines so constructed as to make it possible for the patrolmen to secure help quickly in case of fire. The total cost of protection for the area under patrol was 2 cents per acre, which included the initial cost for fire lines, tool stations, etc. As a result of the first year's work, the loss by fire was practically nothing, the few fires which really started having been speedily discovered by the patrolmen and extinguished without assistance.

In view of the success of the plan during the first year it was extended during 1906 to cover all the holdings of the company. These holdings are extensive and fairly well consolidated, and it will take a considerable time to cut over the present virgin stand. More important than this is the topographic character of the tract, which renders logging both easy and cheap. This, perhaps more than any other one thing, justifies the leaving of trees for a future cut, since the comparatively level nature of the country will make it possible to return again and log profitably, even where the stand per acre is relatively small. The cheapness of the protection secured on the McCloud tract and its thorough efficiency should serve as an object lesson to other owners of forest lands.

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During the past year an efficient organization of lumbermen in northern Idaho has been formed, cooperating with the State, and known as the State and Lumbermen's Protective Association. The object is the prevention and control of forest fires on lands outside the national forests under private, corporative, and state ownership. Under the state law, wardens and deputies are appointed upon whom police powers are conferred. A paid patrol is maintained, and where necessary, temporary laborers are employed for fire fighting, the expense being apportioned among the respective owners and the State in proportion to the acreage of holdings involved. A complete system of trails has been outlined and work begun in many places. The patrolmen employed by the association are chosen on the basis of merit and their familiarity with the region in which they are to work. As a result of the adoption of the plan, a feeling of mutual interest has grown up between the State, lumber companies, individual owners of timber land, settlers, and all who are desirous of preventing and suppressing fires. There has also been cordial cooperation between the association and the Forest Service. Fires outside the national forests but near their boundaries were discovered by rangers of the Forest Service, who promptly notified the proper officials of the association. During this time the officers of the association were having their hands more than full with forest fires all over northern Idaho. In some instances the officers of the Protective Association were unable to handle the fires reported to them by the rangers, and in these cases the rangers, acting under the authority of the association, secured men and supplies and extinguished the fires, the expense of same being met by the association. In other instances the association put men and supplies at the disposal of the forest officers in fighting fires within the boundaries of the national forest.

On the Pacific coast the best example of cooperation among private owners is the Washington Fire Association, with headquarters at Seattle. This organization was effected early in 1908. It was incorporated under the laws of Washington "for the preservation of the forests of the State of Washington generally, and particularly from loss by forest fires, and the enlistment of the aid of the United States of America and the State of Washington in preserving said forests and preventing their destruction by fire."

The membership of the association includes 138 of the largest owners of timber lands in the Northwest, representing holdings aggregating 2,600,000 acres, 75 per cent of which is held by 8 or 10 companies. An assessment of 1 cent per acre for the season was levied. The amount thus secured was sufficient to carry the operations through the season, but had early rains not occurred, an additional levy of at least one-half cent per acre would have been necessary, as the fires were becoming larger and harder to handle. The timber companies were compelled to organize for protection, since the $7,500 appropriated by the legislature was sufficient only to maintain the office of the state firewarden and forester and to pay the salaries and expenses of the deputy firewardens in the different counties.

The administrative work of the association is conducted by the chief firewarden. During the season of 1908 the association had 75 men in the field from June 15 to September 15. These men were appointed forest rangers at large under the provisions of the state

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law, which gives authority to make arrests without warrant of persons violating the fire law. The State was divided into districts, each man covering approximately four townships. Seven inspectors were appointed, each one having charge of from 7 to 12 rangers. Weekly reports were required and suitable equipment furnished, consisting of ax, hoe, and water bag. In addition, tools, such as shovels, mattocks, saws, and buckets, were stored at convenient places. Most of the men were mounted on horses, some used wheels, and a few went on foot, owing to the country being too rough to permit the use of a horse. Every man was instructed to notify the deputy firewarden in the county and also the chief firewarden at Seattle by telephone or telegraph in case of a serious fire.

Most of the fires occurred during July and August, and the great majority were started from railroad locomotives and donkey engines. During these months the rangers extinguished 838 camp and other small fires covering not more than a few square rods; 162 small forest fires extinguished without any extra help or expense, generally not covering more than 5 acres; and 102 large fires, requiring extra help and expense; total, 1,102 fires. There were 18,773 acres of land burned over, of which 743 acres were timbered; of this it is estimated by the chief firewarden, Mr. D. P. Simons, jr., that one-half was damaged. There were employed 607 men, the total amount spent for fire fighting amounting to about $4,000, in addition to the salaries of the men under appointment. While excellent work was accomplished, considering the newness of the work and the number of men available, there is no question but that, as stated by Chief Firewarden Simons, twice the number of men actually employed should have been on duty.

In addition to the patrol and fire-fighting work, great good was accomplished by the forest rangers in inspecting logging locomotives and donkey engines and sawmills located in forest regions, and enforcing the law requiring efficient spark arresters. Companies operating logging locomotives, donkey engines, or mills not so equipped were allowed five days in which to comply with the law, and the request of the chief firewarden along this line was in every instance met by prompt compliance on the part of the company concerned.

It has been impossible to secure similar cooperation on the part of the railroads, according to Chief Firewarden Simons. The companies all claim to have a screen set diagonally in front of the tubes. This, however, is almost never kept in proper repair, owing to its serious interference with the steaming power of the locomotive. The coal used is of a poor grade and clogs the screens, so that the engineer usually opens the front and punches the screen full of holes. Mr. Simons believes that until a better grade of coal is used on the coast, or oil burners are adopted, there will always be trouble with forest fires caused by the railroads. An attempt was made by the association to induce the railroads to put on track patrolmen, but the only concession secured was the assurance that the section crews would assist in case of fires along the right of way.

Mr. Simons favors the appropriation by the State of $125,000 per year for fire protection. This would provide a sufficient field force to see that slashings are burned at the proper time, thus reducing the fire risk to a minimum. The cooperative establishment of telephone

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lines to reach inaccessible regions is another measure favored by the association which would aid greatly in securing proper fire protection.

In Wisconsin steps have been taken looking to the formation of associations for the prevention and control of forest fires similar to those in Idaho and Washington. The initiative has been taken by the state forester. The plan is to appoint patrols, to be employed during the dry season, the expense to be apportioned among the owners interested in proportion to the areas of their holdings. These patrols, when employed, would be appointed firewardens under authority of state law, and would receive every possible assistance and cooperation on the part of the state forester and other state officials.

In Connecticut the various water companies are especially active in fire prevention. Most of them have their superintendents appointed district firewardens. In the town of Simsbury the New York, New Haven and Hartford Railroad Company has cooperated with the authorities in establishing a fire patrol during April and May. The railroad company pays one-half of this expense, the town a portion, and the adjoining landowners the remainder. Some 40 fires were this year extinguished by this patrol, which would otherwise have burned over a large area that has been annually burned.

The Pennsylvania Railroad Company, operating in the eastern portion of the United States, has made some progress along the lines of fire protection. The problem is confined mainly to the prevention of fires on timber lands or wood lots owned or controlled by the company and along rights of way where injury to adjoining property might result in damage suits. On a watershed property of about 9,000 acres a firewarden has been employed during the spring and fall seasons for the past two years, who has patrolled the track and reported to the Altoona office any fires which he could not control. The results have been very satisfactory and no serious damages have occurred. In addition to the patrol, notices have been posted on several tracts calling attention to the danger from fire, and requesting the assistance and cooperation of all campers, berry pickers, etc. As a general measure of protection, and one which has proved very efficient, all employees in divisions which run through forested or brush lands are instructed at the beginning of the spring fire season to keep a look out for fires, extinguish those which they are able to reach and control, and report all others to division headquarters. These orders apply to trackmen, and as a result of the vigilance of a large number of men, fires have little opportunity to get beyond control before being reported. Probably the most dangerous region, from the standpoint of fires started from locomotive sparks, is in the southern part of New Jersey. Here, for many miles along the Cape May division and on the Newfield branch, a strip 100 feet wide on each side of the track is cut clean and burned over once or twice a year. On the outside of the strip furrows are plowed to prevent grass fires which start near the track from running into adjacent woodlands. The difficulty in this kind of protection is that the landowners frequently object to having such a strip cleared, and through the popular desire to hold up the railroads, the tendency is to charge a rental which makes such work prohibitive. Nevertheless, much good has been accomplished in the shape of fire prevention in this way.

In the South the best example of fire protection is the Pisgah forest, owned by the Vanderbilt estate, with headquarters at Biltmore, N. C.

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This forest has an area of 130,000 acres, and has been under conservative forest management during the past twelve years. Protection against fire was the most serious problem which had to be met during the first years of management. The general policy has been to enforce strictly the fire and stock laws of the region, while at the same time cultivating in every possible way the friendship and good will of the native population and educating them to respect owners' rights and to see that the prevention of forest fires and of unrestricted grazing is for the best interests of the country as a whole. This policy has secured excellent results. Infractions of the fire and stock laws have been followed up vigorously as far as evidence could be obtained, as well as ordinary trespass, poaching, and theft of timber. The estate during the first few years experienced a great deal of trouble in these respects, with damage suits on hand much of the time. Within the last few years, however, trouble of this sort has greatly decreased. Moreover, the careful system of protection established on the tract has had a moral influence upon the native population. On the greater part the rangers claim that practically no spring fires are now started intentionally, and that there is very little trouble with the stock. The rangers keep on good terms with the natives as far as possible and show them the evil effects of fire and heavy grazing and the objects of the protective system on the estate.

This method has proved very successful, and as a result the local mountaineers have largely discontinued the practice of firing their own lands to improve grazing. Protection against fire is the principal duty of the head rangers. The ranges are marked out in regular sections across the tract, each including a portion of the high mountains on the Pisgah Range. On each range a number of elevated peaks have been selected from which practically the entire area can be clearly seen and fires readily detected. During any time of drought and fire danger these points are patrolled constantly, in some cases day and night, by assistant rangers, who are nearly always tenants on the tract. The main mountain patrol is usually made by men in pairs. When a fire is discovered one of these men hastens to it with all available help. The other hunts up and informs the head ranger and then collects a crew of fire fighters from the tenants on the range. The tenants, moreover, form a fire-fighting staff, loyal to the estate, equipped with saddle horses, and thoroughly acquainted with the region. They can be called upon at any time to fight the larger fires or to do special patrol work. A permanent staff of this kind makes the estate independent of outside help and avoids the danger of outsiders starting fires in the hope of securing employment. Between the tenants and the regular rangers, fires are usually quickly detected and extinguished. The roads and trails form a good network of fire lines, and are furthermore of the utmost value in protection, because they furnish rapid communication between all parts of the tract.

When a fire has not yet gained much headway, or is burning against the wind, or when the woods are comparatively moist and not burning readily, or the fire as usual in the fall is confined to the leaves, the men form a line and beat it out directly with hemlock boughs, sacks, or bunches of hard-wood twigs.

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When the fire is well under way, especially if the woods are dry and burning fiercely, with a good deal of combustible material on the ground, or if the fire is running with the wind, the men begin at once to back fire. They usually work in crews of eight. Two men go ahead with pitchforks, clearing a strip about 5 feet wide of combustible material. Two others follow with rakes, completing the clearing of the strip by raking off the leaves and smaller twigs. Care is taken to direct the line well away from down timber or logs and dead stubs or stumps which might enable the back fire to jump the trail. Two more men follow, firing the leaves on the side of the strip toward the blaze, the rest of the crew spreading out along the strip at close intervals to see that the fire does not jump the cleared path. The lane and back fire can in this way be run very rapidly, often at the rate of a mile or a mile and a half an hour.

The system of protection used on this tract, while expensive, appears to be very effective. The aim is to keep out fire at any cost. No risk is taken that can be avoided at reasonable expense, under the general plan of spending money to keep out fire rather than in fighting fire after it once gets in. In this way thoroughgoing protection has been secured, though at an annual cost of probably 4 cents an acre.

CONCLUSION.

The direct loss to the United States each year from forest fires is not less than $50,000,000. The indirect losses are beyond calculation, but are certainly several times as great as the direct loss. Experience both in Europe and the United States shows conclusively that loss from forest fires is practically preventable at reasonable expense. Except on the National Forests and in a few isolated instances the measures adopted are totally inadequate to meet the needs of the situation. What is needed is a general realization by the public of these facts, followed by the improvement and enforcement of existing laws and the expenditures of adequate sums of money as a business measure, not only by the Federal Government but by the States and by corporations and private owners of forest lands. Further delay is business folly as well as a national calamity.

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WASTE AND REDUCTION OF TIMBER SUPPLIES CAUSED BY INSECTS, AND METHODS OF PREVENTION AND CONTROL.

By A. D. HOPKINS,
In Charge of Forest Insect Investigations, Bureau of Entomology.

CHARACTER AND EXTENT OF DEPREDATION.

The records of notable depredations by insects on the timber supply of Europe during the past four hundred years, and on that of the United States during the past century, and especially those that have come under the observation of the writer and his assistants during the past eighteen years, furnish conclusive evidence that this class of enemies has been, and is now, an important factor in the destruction and waste of forest resources.

CAUSE OF THE DEATH OF TIMBER.

It has been determined that in this country certain species of insects are the direct or primary cause of the death of trees of all ages, and that from time to time they multiply to such an extent as to take the character of a destructive invasion, resulting in the death of a large proportion of the timber of certain species over many square miles.

EXAMPLES.

The southern pine beetle.—A destructive invasion by the southern pine beetle (*Dendroctonus frontalis* Zimm.) in 1890–1892 extended from the western border of West Virginia through Maryland and Virginia into the District of Columbia, northward into southern Pennsylvania, and southward into North Carolina. In this area, aggregating over 75,000 square miles, a large percentage of the mature and small trees of the various species of pine and spruce was killed by this beetle. In certain localities in West Virginia and Virginia nearly all the pine trees of all sizes were killed on thousands of

[NOTE.—The statements and estimates in this report are based largely on observations and the results of investigations by the writer and his assistants, and information secured through correspondence with forest officials and private owners of timber and manufacturing enterprises. Much of it has been published in the various bulletins and circulars of the Bureau of Entomology, the West Virginia Agricultural Experiment Stations, and in proceedings of societies, etc., but there is also much original matter drawn from the unpublished notes and records of the Branch of Forest Insect Investigations of the Bureau and from the unrecorded experience and observations of the writer. Some of the statements and estimates may seem to be overdrawn or exaggerated, but they are based on available evidences and facts which indicate to the writer that they are conservative.—A. D. HOPKINS.]

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acres, while shade and ornamental trees within the same area suffered the same as those in the forest. It has been more or less active in the States south of Virginia to Texas since 1902, and in some localities and during some years it has killed a large amount of timber. Records of extensive dying of timber in the Southern States are found dating back to the early part of the nineteenth century. Therefore, this species may be considered as one of the most dangerous enemies and a constant menace to the pine forests of the Southern States.

The eastern spruce beetle.—During the period between 1818 and 1900 there were a number of outbreaks of the eastern spruce beetle (*Dendroctonus piceaperda* Hopk.) in the spruce forests of New England and southeastern Canada. It caused the death of a large per centage of the matured spruce over many square miles. The larger areas of this dead timber evidently furnished fuel for devastating forest fires, with the result that in most cases there was a total loss.

The Engelmann spruce beetle.—Another bark beetle of the same genus, and with similar habits, has from time to time during the past fifty years caused widespread devastations in the forests of Engelmann spruce of the Rocky Mountain region, in some sections killing as high as 90 per cent of the merchantable sized timber.

The Black Hills beetle.—One of the most striking examples of the destructive powers of an insect enemy of forest trees is found in the Black Hills National Forest of South Dakota, where during the past ten years a large percentage of the merchantable timber of the entire forest has been killed by the Black Hills beetle (*Dendroctonus ponderosæ* Hopk.). It is estimated that a considerable part of the total stand of timber has died in this forest as the direct result of the work of this beetle. This destructive enemy of the western yellow pine is distributed through the forests of the middle and southern Rocky Mountain region, in which it has been found that within recent years a large amount of timber has been killed by it, not scatteringly through the forests of the entire region, but here and there areas of greater or less extent where from 10 to 80 per cent of the trees have been killed by it.

The mountain pine beetle and western pine beetle.—The sugar pine, silver pine, western yellow pine, and the lodgepole pine of the region north of Colorado and Utah, westward to the Cascades and southward through the Sierra Nevada, are attacked by the mountain pine beetle (*Dendroctonus monticolæ* Hopk.) and the western pine beetle (*Dendroctonus brevicomis* Lec.), and, as a direct consequence, billions of feet of timber have died. In one locality investigated in northeastern Oregon it is estimated that 90 to 95 per cent of the timber in a dense stand of lodgepole pine, covering an area of 100,000 acres, has been killed within the past three years by the mountain pine beetle. Throughout the sugar-pine districts of Oregon and California a considerable percentage of the largest and best trees are dead as the result of attacks by this same destructive bark beetle.

The Douglas fir beetle.—The Douglas fir throughout the Rocky Mountain region from southern New Mexico to British Columbia has suffered severely from the ravages of the Douglas fir beetle (*Dendroctonus pseudotsugæ* Hopk.) resulting in a large percentage of dead timber, much of which will be a total loss.

Three other species of beetles of destructive habits, similar to those mentioned, depredate on the pines of New Mexico and Arizona, and

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still another has contributed greatly to the destruction of the eastern larch throughout the northeastern United States and southeastern Canada.

The hickory barkbeetle.—Within the past ten years the hickory barkbeetle (*Scolytus quadrispinosus* Say) has been the cause of the death of an enormous amount of hickory timber throughout the northern tier of States from Wisconsin to Vermont and southward through the eastern Atlantic States and into the Southern States as far as central Georgia.

The larch worm.—There are many examples of widespread depredations by insects which defoliate the trees and thus contribute to their destruction. Notably among these is the larch worm (*Nematus erichsonii* Hartig), which, during a number of extensive outbreaks since 1880, has killed from 50 to 100 per cent of the matured larch over vast areas in the northeastern United States and southeastern Canada. It is believed that the amount of merchantable sized timber that has died as a result of defoliation by this insect will aggregate many billions of feet.

INJURIES TO THE WOOD OF LIVING TREES.

It has been determined that a certain class of insects attack the wood and bark of living timber and that while they do not contribute materially to the death of the trees or show much external evidence of their presence, they cause wounds in the bark and wormhole and pinhole defects in the wood that often result in reductions in value amounting to from 5 to 50 per cent. The defects in the wood are not detected until after the trees are felled and the logs are transported to the mill and converted into lumber. Thus to the actual damage to the wood is added the expense of logging and manufacture of the defective low-grade material, much of which is discarded as worthless culls.

EXAMPLES.

The oak timber worm.—One of the most destructive of this class of depredators is the oak timber worm (*Eupsalis minuta*). It enters the trunks of living trees through wounds in the bark and at the base of broken or dead branches and extends its "pinhole" burrows in all directions through the solid heartwood. The losses occasioned by this insect in the hard-wood forests of the eastern United States are enormous and usually affect the finest examples of old trees.

The chestnut timber worm.—The chestnut throughout its range is damaged in a like manner by the chestnut timber worm (*Lymexylon sericeum*). Practically every tree of merchantable size is more or less affected and a large percentage are so seriously damaged that the product is reduced to the lowest grade. It is estimated that reduction in value of the average lumber product at any given time is not far from 30 per cent, thus involving extensive waste and an increased drain on the forest to supply the requirements for clear lumber. This insect also attacks the oaks, and especially the red oak, the older trees of which are often as seriously damaged as the chestnut.

The carpenter worm.—The oaks, especially the white oak and red oak, are seriously damaged by carpenter worms of the genus *Prionoxystus*. The holes made by them through the heartwood of the

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best part of the trunks are sometimes one and one-half inches in diameter one way by three-fourths of an inch the other, thus causing serious damage to the wood. These, with other large wood-boring grubs of beetles, sometimes infest the top part of the trunk and larger branches where their continued work results, first, in the dead and so-called "stag-horn" top and, subsequently, in broken, decayed, and worthless trunks.

The columbian timber beetle.—One of the most common defects in white oak, rock oak, beech, whitewood or yellow poplar, elm, etc., is that known to the lumber trade as "grease spots," "patch worm," and black holes. This is caused by one of the timber beetles or ambrosia beetles (*Corthylus columbianus* Hopk.) which makes successive attacks in the living healthy sapwood from the time the trees are 20 or 30 years old until they reach the maximum age. Thus the black hole and stained wood defect is scattered all through the wood of the best part of the trunks of the trees. The average reduction in value of otherwise best grade of timber in many localities amounts to from 25 to 75 per cent. The defect is commonly found in oak and elm furniture and in interior hard-wood finish in dwellings and other buildings.

The locust borer.—The locust, as is well known, suffers to such an extent from the ravages of the locust borer (*Cyllene robiniae*) that in many localities the trees are rendered worthless for commercial purposes or are reduced in value below the point of profitable growth as a forest tree; otherwise this would be one of the most profitable trees in the natural forest or artificial plantation and would contribute greatly to an increased timber supply.

The turpentine beetle and turpentine borer.—While the soft wood or coniferous trees suffer far less than the hard woods from the class of enemies which cause defects in the living timber, there are a few notable examples of serious damage. There is a common trouble affecting the various species of pine throughout the country known as basal wounds or basal fire wounds. It has been found that a large percentage of this injury to the pine in the States north and west of the Gulf and the Middle and South Atlantic States is caused by the dark red turpentine beetle (*Dendroctonus valens* Lec.), and in the Southern States by the black turpentine beetle (*Dendroctonus terebrans* Oliv.). These beetles attack the healthy living bark at and toward the base of the trunks of medium to large-sized trees and kill areas varying from 1 to 10 square feet. This is subsequently burned off by surface fires and is then generally referred to as fire wounds. The further damage to the exposed wood by successive fires, decay, and secondary insects often results in a total loss of the best part of the tree, or a reduction in values of from 10 to 50 per cent of the lower section of the trunk. These and similar wounds in the bark of trees, including those caused by lightning and by the exposure of the wood in turpentining, offer favorable conditions for the attack of the turpentine borer (*Buprestis apricans*). The work of this insect and two or three others with similar habits is very extensive and causes losses amounting to 10 to 50 per cent of the wood of the best part of the trees thus affected.

The white pine weevil.—The abnormal development of white pine trees as the result of successive attacks on the terminals of saplings and young trees by the white pine weevil (*Pissodes strobi* Peck)

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is an element of loss of considerable importance, especially in mixed stands and in open pure stands of this timber. The value of such trees is reduced 20 to 50 per cent, and there is an additional loss from the effect of their spreading branches or crowns in the suppression or crowding out of trees which would otherwise occupy the space thus usurped.

There are many other examples of damage by insects to the wood and bark of living trees, but those mentioned should be sufficient to demonstrate the importance of insects in their relation to injuries to the wood and growth of living timber.

INJURY TO THE WOOD OF DYING, AND DEAD TREES.

Timber dying and killed by insects and other causes, including fire, disease, storm, etc., is attacked by a class of wood-boring insects which extend their burrows through the sound sapwood and heartwood and thus contribute to the rapid deterioration and decay of a class of resource which otherwise would be available for utilization during periods of from one to twenty years or more after the death of the trees, depending on the species of trees and character of product desired. This loss often amounts to from 25 to 100 per cent during the period in which the dead timber would otherwise be almost as valuable as living timber.

EXAMPLES.

CONIFERS.

Sawyers.—One of the striking examples of the destruction or deterioration of dying and dead timber familiar to all lumbermen is the injury to fire-killed and storm-felled white pine caused by boring grubs known as sawyers. Pine, fir, spruce, etc., are affected. These borers hatch from eggs deposited by the adult beetles in the bark of the dying trees, and after feeding on the inner bark for a time they enter the solid wood and extend their large burrows deep into the heartwood. Fire-killed white pine is especially liable to this injury, and is often so seriously damaged within three or four months during the warm season as to reduce materially the value of the attacked timber. The shortleaf, loblolly, and longleaf pine of the Southern States are damaged to a somewhat less extent, but examples are known of storm-felled timber within limited areas being reduced in value 25 to 35 per cent within three months after the storm. The fire and insect killed sugar pine, silver pine, and yellow pine of the western forests are also damaged in a similar manner, and the value of the product greatly reduced within a few months after the trees die. The losses from this secondary source in the coniferous forests contribute greatly to the annual waste of millions of dollars' worth of forest products.

Ambrosia beetles.—There is another class of wood-boring insects known as "timber beetles" or "ambrosia beetles," which cause pinhole defects principally in the sapwood, but some of them extend their burrows into the heartwood. These insects make their attack in the early stage of the declining or dying tree or before the sapwood has materially changed from the normal healthy condition, and often in such numbers as to perforate every square inch of wood.

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The wood is thus not only rendered defective from the presence of pinholes, but the holes give entrance to a wood-staining fungus, which causes a rapid discoloration and still further deterioration of the product.

The value of the sapwood of trees dying from insect attack, fire, storm, and other causes is often reduced 50 per cent or more, and in some cases the value of the heartwood is reduced in a like manner 5 to 10 per cent.

Pin hole borers in cypress.—Another example of the destructive work of this class of insects is found in the cypress timber in the Gulf States, where the trees are deadened by the lumbermen and left standing several months or until it is dead and sufficiently dry to float. Upon investigation it was found that trees deadened at certain seasons of the year were attacked by the ambrosia beetles, and that in some cases the value of millions of feet of timber had thus been reduced 10 to 25 per cent or more.

HARDWOODS.

Roundheaded timber worms and ambrosia beetles.—The principal damage to dying and dead hardwood trees is caused by certain roundheaded (Cerambycid) wood borers, with habits similar to the sawyer, and by the timber worms mentioned as damaging living timber; also by ambrosia beetles, with habits similar to those that attack the sapwood and heartwood of conifers. All of the hardwoods suffer more or less, but the greatest damage is done to the wood of hickory, ash, oak, and chestnut, which are often reduced in value 10 to 25 per cent or more within the period in which the wood would otherwise be sound and available for utilization.

INJURY TO FOREST PRODUCTS.

During the process of utilizing forest resources, from the time the trees are felled until the logs are converted into the crude and finished product, and until the latter reaches the consumer, or even after it is placed in the finished article or structure, damage is caused by various species of insects which are attracted by the varying conditions prevailing at different stages in the process. As a result, additional drains are made on the timber to meet the demand for the higher grades of lumber and other supplies to replace that which has been injured or destroyed. From the writer's personal investigations of this subject in different sections of the country, the damage to forest products of various kinds from this cause seems to be far more extensive than is generally recognized. This loss differs from that resulting from insect damage to natural forest resources in that it represents more directly a loss of money invested in material and labor.

EXAMPLES.

Crude Products.

Roundheaded borers, timber worms, and ambrosia beetles.—Round timber with the bark on, such as saw logs, poles, posts, mine props, etc., are subject to serious damage by the same class of insects as those mentioned under character of injury to dying and dead trees.

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The damage is especially severe when material is handled in such a manner as to offer favorable conditions for attack, such as leaving the logs in the woods on skidways or in mill yards for a month or more after they have been cut, when under such conditions there is often a reduction in value of from 5 to 30 per cent or more, due to wormhole and pinhole defects caused by roundheaded and flatheaded wood borers and timber beetles. Frequently the insects continue the work in the unseasoned and even dry lumber cut from logs which had been previously infested. They also continue to work in mine props after they have been placed in the mine, and in logs and other material used for the construction of cabins, rustic houses, etc., and in round timbers generally.

The products from saplings, such as hickory hoop poles and like material, are often seriously injured or rendered worthless by roundheaded and flat-headed borers and wood-boring beetles, sometimes resulting in a great loss of the merchantable product.

Stave and shingle bolts left in moist, shady places in the woods or in close piles during the summer months are often attacked by ambrosia beetles and timber beetles. The value of the product is, in consequence, often reduced 10 to 50 per cent or more.

Handle and wagon stock in the rough is especially liable to injury by ambrosia beetles and roundheaded borers. Hickory and ash with the bark on are almost certain to be greatly damaged if the logs and bolts cut from living trees during the winter and spring are held over a few weeks after the middle of March or first of April.

Pulp wood, and cord wood for fuel and other purposes, cut during the winter and spring and left in the woods for a few weeks or months, or in close piles after the beginning of the warm weather, are sometimes riddled with wormholes or converted into sawdust borings, causing a loss of from 10 to 100 per cent. One example reported from near Munising, Mich., represents a loss of $5,000 from injury to spruce and fir pulp wood cut in the winter and kept in piles over summer.

Manufactured Unseasoned Products.

Ambrosia beetles and other wood borers.—Freshly sawed hardwood placed in close piles during warm, damp weather during the period from June to September is often seriously injured by ambrosia beetles. Heavy two to three inch stuff is also liable to attack by the same insects, even in loose piles. An example of this was found in some thousands of feet of mahogany lumber of the highest grade which had been sawed from imported round logs and piled with lumber sticks between each tier of plank where native species of ambrosia beetles, principally *Pterocyclon mali* Fitch, had entered the wood to such an extent as to have reduced the value 50 per cent or more within a few weeks. Oak, poplar, gum, and other similar woods often suffer severely from this class of injury, causing losses varying from 5 to 50 per cent.

Lumber and square timbers of both soft and hard woods with the bark left on the edges are frequently damaged by flat-headed and roundheaded wood borers which hatch from eggs deposited in the bark before or after the lumber is sawed. There are examples of losses from this character of injury amounting to 20 to 50 per cent or more.

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Telegraph and telephone poles, posts, mine props, etc., are frequently injured before they are set in the ground, especially if the bark remains on them during a few weeks after the middle of March.

Seasoned Products in Yards and Storehouses.

Powder post beetles.—Hardwood lumber of all kinds, rough handle and wagon stock, etc., partially or entirely of sapwood, are often reduced in value 10 to 90 per cent by a class of insects known as "powder post beetles." The sapwood of hickory, ash, and oak is most liable to attack. The reported losses from this source during the past five or six years indicate that there has been an average reduction in values of from 5 to 10 per cent or more.

Old hemlock and oak tan bark are often badly damaged by various insects which infest dead and dry bark that in some tanyards as much as 50 to 75 per cent of the bark that is over three years old is destroyed. In one tannery in West Virginia it is estimated that more than $30,000 worth of hemlock bark was thus destroyed.

Finished and Utilized Products.

Finished products.

Powder post beetles.—It is in the finished hardwood products, such as handles, wagon, carriage, and machinery stock, that the greatest damage and loss is occasioned by powder post beetles. This is especially true of hickory and ash handles and like products in storehouses, including the vast amount of material held in storage for the army and navy. When material of this kind is once attacked it is usually worthless for the purposes indicated, and therefore must be replaced with new material. In some cases losses have amounted to from 10 to 50 per cent, and it is estimated that the average losses have been as much as 10 per cent on all sapwood material that has been in storage more than one year.

Utilized products.

Powder post beetles and other wood borers.—The finished woodwork in implements, machinery, wagons, furniture, and inside finish in private and public buildings is often seriously damaged by powder post beetles.

Construction timbers and other woodwork in new and old buildings are often so seriously damaged by powder post beetles, white ants, and other wood-boring insects that the affected material has to be removed and replaced by new or the entire structure torn down and rebuilt.

Construction timbers in bridges and like structures, railroad ties, telephone and telegraph poles, mine props, fence posts, etc., are sometimes seriously injured by wood-boring grubs, termites, black ants, carpenter bees, and powder post beetles, and sometimes reduced in efficiency from 10 to 100 per cent.

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INSECTS IN THEIR RELATION TO THE REDUCTION OF FUTURE SUPPLIES.

Insects not only reduce future supplies by killing the matured trees and destroying timber that is inaccessible for utilization, but through injuries during the flowering, fruiting, germinating, seedling, and sapling periods of early growth, prevent normal reproduction and development.

INTERRELATION OF INSECTS AND FIRE.

DURABILITY OF INSECT-KILLED TIMBER.

Timber killed by insects and fire would be available for utilization for many years were it not for injuries through secondary attacks of wood-boring insects and the destruction of insect-killed timber by forest fires. Some of the matured larch trees, evidently killed by the larch worm between 1881 and 1885, that had escaped subsequent depredations by fire and wood-boring insects, are now (1908) standing, and sound enough to be utiilzed for railroad ties and many other purposes. The heartwood of red spruce and Engelmann spruce, Douglas fir, white pine, etc., has been found by the writer to be sound enough for profitable utilization for pulp wood, lumber, fuel, etc., twenty to thirty years after it had been killed by insects or fire.

INSECT-KILLED TIMBER DESTROYED BY FIRE.

It has often happened that after insects had killed the timber over extensive areas forest fires followed and destroyed the dead timber. Indeed, abundant evidence has been found during recent investigations to prove that some of the denuded areas in the Rocky Mountain and other sections of the country are primarily due to devastations by insects, and that subsequent fires destroyed the timber and prevented reproduction.

FIRE-KILLED TIMBER INJURED BY INSECTS.

On the other hand, there is a vast amount of timber which has been killed outright or has died as the direct result of forest fires, but in every observed case insects have contributed more or less to the death of fire-scorched trees, which otherwise might have recovered, and especially to the rapid deterioration of a large per cent of the injured and killed trees. It is evident that in some cases fire-scorched and fire-killed timber has contributed to the multiplication of one or more of the destructive enemies to the living timber, and thus the injury started by the fire may have resulted in a destructive invasion of beetles. However, it is evident that this has happened only when the destructive beetle was already present in abnormal numbers in the forest surrounding the fire-swept area. Therefore, it is believed that injuries by fire are not as a rule an important factor in contributing to subsequent depredations by bark beetles. Such fires do, however, contribute to the multiplication of the insects which depredate on the wood, so that in forested areas where fires are frequent the damage to dying and dead trees is more severe, and fewer injured trees recover on account of the abundance of secondary bark-beetle enemies which do not, as a rule, attack living timber.

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DESTRUCTION OF INSECTS BY FIRE.

There is another important feature in the relation of insects and fire, in which the fire contributes to the destruction of the principal bark-beetle enemies of the living timber. This happens when the fire burns the timber while it is infested, and thus effectually destroys the broods of the insects before they emerge. It is perfectly plain that the dying and dead foliage of the beetle-infested trees and the dead bark on the trunks would contribute to the starting and spread of crown fires, and thus the bark on the entire infested trunks would be sufficiently scorched to kill the insects. Therefore complete fire control may easily contribute to more extended depredations by insects on the living timber.

INTERRELATION OF FOREST INSECTS AND FOREST FUNGI.

DECAY FOLLOWS INJURY BY INSECTS.

It is well known that the burrows in the bark and wood of living and dead trees and in the crude and finished products often contribute to the entrance of bark and wood decaying fungi. Deterioration and decay are thus far more rapid than would otherwise be possible. It is also known that trees injured and dying from evident primary attack of parasitic fungi are attractive to certain insects which breed in the bark and wood of sickly and dying trees, and that certain other complicated troubles affecting forest trees are the result of an intimate interrelation and interdependence of insects and fungi. There can be no doubt, however, that certain species and classes of both insects and fungi are independently capable of attacking and killing perfectly vigorous and healthy trees.

BARK BEETLES KILL TREES IN AMERICA.

While there has been some question in European and other literature as to whether bark beetles ever attack healthy timber and kill it, the extended investigations by experts in this country, including detailed studies and experiments, have resulted in the accumulation of abundant evidence to prove conclusively that there are many species of bark beetles and other insects which not only attack perfectly healthy trees, but that they do so through preference and necessity. Furthermore, that they are not only capable of causing serious injury to trees during growth but they have killed century-old trees, and therefore are capable of killing a very large per cent of all of the pines, spruces, or larch within the area of their normal distribution.

SUMMARY OF CHARACTER AND EXTENT OF WASTE CAUSED BY INSECTS.

The killing of trees by insects; the damage to living timber and to crude and finished products by insects; the damage by fire following attack by insects after fire; and the damage from decay as the result of insect injury to trees previously injured and killed by both insects and fire, have been, and are now, continuing throughout the forested areas of the country, including private parks and the farmers' wood-

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lots. Though not always evident in some forests or sections, yet every year, or series of years, there are conspicuous and widespread depredations somewhere in the forests of the country. In every forest and woodlot there is an ever-present but inconspicuous army of insects which requires for food and breeding places the bark, wood, foliage, and seeds of the various commercial tree species. The damage wrought in a single locality by these general enemies of the forests may not be noticed in a single year, but the accumulated injuries wrought during the period required for the growth of a tree from a seedling to commercial size goes far toward reducing the annual average increment below the point of profitable interest on private and public holdings.

The accumulated damage to crude, finished, and utilized products reduces the profits of the manufacturer, increases the price of the higher grades to the consumer, and results in an increased drain on the natural resources.

ESTIMATES.

In any attempt to estimate the extent of losses or waste of timber supplies to be expressed in dollars or feet, there are many conflicting factors which prevent reliable conclusions, in addition to the fact that we have no accurate information as to the actual amount in board feet of standing timber in the country and consequently no accurate data or average cash values. The same holds good, but to a less degree perhaps, with regard to percentages of damaged and destroyed supplies to that unaffected by insects. Therefore, until more complete data can be furnished by experts on forest statistics, any predictions must be based on estimated statistics and the facts and evidences observed by the writer and his field assistants, correspondents, etc., relating to the principal forest areas of the entire country, which are believed by the writer to be conservative, and he is confident that accurate statistics of the existing conditions in the country at this time would fully support it.

REDUCTIONS IN THE NATION'S WEALTH.

If the resources in merchantable timber and forest covers are considered as an element of the nation's wealth, as an asset of a given value to the people for direct utilization, protection to the land from erosion, protection of headwater streams and of game, and as contributing to the attractiveness of health and pleasure resorts, it would be difficult indeed to estimate the amount or per cent of losses or the reduction in values chargeable to insects. It is plain, however, that in the aggregate it would amount to an enormous sum.

REDUCTION IN VALUE OF COMMERCIAL AND FINISHED PRODUCTS.

If we consider the aggregate loss to the trade and to manufacturers and consumers of finished products caused by insects, it is evident that it would amount to many millions of dollars annually, in addition to increased drain on the forest to replace woods prematurely destroyed by insects.

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METHODS OF PREVENTION AND CONTROL.

POSSIBILITIES OF CONTROL.

The results of extensive investigations and of practical applications during recent years have demonstrated that some of the most destructive insect enemies of American forests and of the manufactured and utilized products can be controlled, and serious damage prevented, with little or no ultimate cost over that involved in forest management and business methods.

There are, of course, certain insects and certain injuries which under present conditions and available information can not be controlled or prevented, but it is very evident that if the information now available through the publications of the Department of Agriculture and through direct correspondence with its experts be properly utilized in the future, it will result in the prevention of at least 30 per cent of the estimated annual waste of forest resources caused by insects.

GENERAL METHODS OF CONTROL.

The ordinary spraying and similar methods of dealing with fruit and shade tree insects are, of course, not available for practical application in the case of forest trees.

In all efforts to control an outbreak or prevent excessive losses, it should be remembered that as a rule it is useless to attempt the complete extermination of a given insect enemy of a forest tree or forest product. Experience has demonstrated that it is only necessary to reduce and weaken its forces at least 75 per cent, so that it can not continue an aggressive attack, but must occupy a defensive position against its own enemies and become dependent upon favorable conditions resulting from avoidable negligence and mismanagement by the owners of the forests and manufacturers of forest products, thus can be easily kept under control by good management.

The desired control or prevention of losses can often be brought about by the adoption or adjustment of the requisite details in forest management and in lumbering and manufacturing operations, storing, transporting, and utilizing the products, which at the least expenditure will cause the necessary reduction of the injurious insects and establish unfavorable conditions for their future multiplication or continuance of destructive work.

It is, however, of the utmost importance that any adjustment or modification in management or business methods should be based on expert technical knowledge or advice relating to the species, habits, life history, and natural enemies of the insects involved and on knowledge of the essential features of methods of control. This should be supplemented by expert knowledge or advice on the principles of technical and applied forestry in the proper management, care and utilization of the forests and its resources, and still further supplemented by practical knowledge and experience relating to local conditions and facilities.

As has been shown, the matured or merchantable-sized timber is most liable to injury or death from the ravages of insects. Therefore, considered from the standpoint of insect control and the prevention of one of the greatest items of loss, it is important that such

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timber should be utilized before it begins to deteriorate, or before it reaches the stage of unprofitable growth.

In order to be most successful in dealing with forest insects it must be recognized that each species differs to a greater or less extent from all other species, even of the same genus; that there are also certain characteristics of the different tree species which differ from those of all other tree species; and that as a rule it is the technical knowledge of these peculiar features or characteristics of the trees and their enemies which furnishes the clue to successful methods of control.

There are also many peculiar features in prevailing conditions in different localities, some of them favorable, others unfavorable, for the practical application according to a given method, so that while certain general advice may apply in a broad sense, it is often necessary to diagnose a given case before specific expert advice can be given as to the exact cause and the most effective method to be adopted, just as a physician must diagnose a case of illness or injury before prescribing the necessary treatment for his patient.

Therefore, in answering the question of the commission as to how far the waste of forest resources caused by insects can be prevented and how far the damaged timber can be utilized, we will attempt to give only general statements, based on the results of our observations, relating to some of the principal character of losses discussed in the first part of this report, namely, insects which (1) kill the trees, (2) cause injuries to the wood of living timber, (3) reduce future supplies, (4) cause injuries to the products; (5) the utilization of natural enemies of injurious insects, (6) the utilization of damaged timber, and (7) present conditions and opportunities.

CONTROL OF BARK BEETLES WHICH KILL TREES.

The bark beetles which kill trees attack the bark on the main trunk and destroy the life of the tree by extending their burrows or galleries in all directions through the inner living bark. The broods of young grubs or larvæ develop within the inner bark, on which they feed. Those of some species develop to the adult stage within the inner bark and are exposed when the bark is removed, while those of other species transform to the adults in the outer corky bark and the larvæ are not exposed when the bark is removed. Some species have two or more seasonal or annual generations, while others have but one, and in a few species it requires two years for a single generation to develop.

The bark beetles of the genus *Dendroctonus* represent the most destructive enemies of the principal coniferous American forests, and at the same time are among the easiest to control. The general requisites for success are embodied in the following rules:

(*a*) Give prompt attention to the first evidence of a destructive outbreak, as indicated by an abnormal per cent of yellow or red topped dying trees, and especially when such trees occur in groups of 10 or more or cover large areas; (*b*) secure authentic determination of the particular species of insect responsible for the trouble; and (*c*) take prompt action toward their control according to specific expert advice on the best method for the destruction of the necessary 75 per cent or more of the insects in the infested trees.

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Some of the methods to be adopted to meet the requirements of various local conditions are as follows:

1. Utilize the infested timber and burn the slabs during the period in which the broods of the destructive beetles are in the immature stages or before the developed broods emerge from the bark; or

2. Fell the infested trees and remove the bark from the main trunk and burn the bark, if necessary;[a] or

3. Remove the infested bark from the standing timber and burn the bark, when necessary;[a] or

4. Immerse the unbarked logs in ponds, lakes, or streams, where the bark will remain soaked long enough to kill the insects; or

5. Remove the unbarked logs or products to a locality where there are no trees liable to attack within a radius of 20 miles or more.

TO MAINTAIN CONTROL OF BARK BEETLES.

Future trouble of a serious nature from this class of insects can be prevented if an insect-control policy is adopted in connection with, or independent of, a fire-control policy by which groups of dying trees will receive the same prompt attention as that given to forest fires.

Applications in state and national forests.—In all forest reserves in which there is an organized force of rangers and firewardens or opatrols, each officer should be furnished with instructions as to the location of beetle-infested trees, and with equipments and directions for taking the necessary action whenever the conditions demand it.

Private forests.—Private forests should receive the same attention as public forests, but it is often far more difficult on account of intervening forests, where the owners either can not or will not give the matter the required attention. While it may be advisable to have some laws to govern the treatment of timber infested with a dangerous pest when the owner refuses to take any action, such laws should apply only to the more extreme cases or as a last resort on authoritative advice. It is probable that in most cases legislation will not be necessary, and more ultimate good will result without than with strict laws, especially when it can be made clear to the owner that his personal interests demand that he take the proper action and that, when necessary, his neighbors will render assistance, as is often done in the case of a forest fire.

Inaccessible areas.—There are yet large, inaccessible areas in the East and West where it is not practicable or possible at present to attempt to control the depredations by these beetles, and therefore they must be left to the natural adjustment that has been going on in all primitive forests from the beginning. While under such natural control much of the older matured timber will be lost, it will usually be replaced by young growth, either of the same or of different species, so that under normal conditions the forest will be perpetuated, but under exceptional conditions and combinations of detrimental influences, such as secondary insect enemies, fire, drought, etc., extensive areas may be completely denuded, never to be refor-

[a] If the broods develop to adults in the outer bark it must be burned; if they develop in the inner bark and are exposed when the bark is removed, burning is not necessary. As a rule the burning of the tops to destroy the insects is not necessary.

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ested under natural conditions. Therefore it will evidently not be very long before it will pay to adopt insect-control policies in areas that are inaccessible for profitable lumbering.

EXAMPLES OF SUCCESSFUL CONTROL OF BARK BEETLES.

The following examples of successful control of depredations by the destructive bark beetles are sufficient to demonstrate the practicability of advice based on the results of entomological investigations.

CONTROL OF THE EASTERN SPRUCE BEETLE.

The control of an alarming outbreak of the eastern spruce beetle (*Dendroctonus piceaperda* Hopk.) in northeastern Maine in 1900 and 1901 was effected by the concentration of regular logging operations in the areas of infested timber and placing the logs in lakes and streams and driving them to the mills on the Androscoggin River. Thus, with little or no additional expense, there was a saving to one firm, according to its estimates, of more than $100,000.

CONTROL OF THE BLACK HILLS BEETLE.

An extensive outbreak of the Black Hills beetle (*Dendroctonus ponderosæ* Hopk.) in the vicinity of Colorado Springs, Colo., in 1905–6, which was threatening the living pine timber of the entire section, was brought under control through the efforts of the private owners of forests and of officials in the adjoining national forests, by cutting and barking about 1,000 beetle-infested and beetle-killed pine trees. The cost of the operations was largely, if not entirely, covered by the utilized felled timber, although considerable unnecessary expense was involved through the felling and barking of trees from which the beetles had emerged, also from the unnecessary burning of the bark and tops.

The successful control of another serious outbreak of the Black Hills beetle in 1906 on an extensive private estate in southern Colorado was effected through the efforts of the owners, who had some 500 infested trees felled and barked within the necessary period to destroy the broods. A large per cent but not all of the infested timber was thus treated. So thorough was the work that not a single infested and dying tree could be found when the area was inspected in 1908. In this, as in the other case, considerable unnecessary expense was involved in the burning of the bark and tops, but the utilizable timber was worth more than enough to pay all expenses. It is evident that in this case a destructive invasion was prevented.

The most striking example of success in control of the Black Hills beetle has recently been reported. In May, 1907, Mr. W. D. Edmonston, a forest ranger, detailed from the Forest Service to the Bureau of Entomology, to work under our instructions in locations of beetle infestation in the national forests of Colorado and adjoining States, reported that the pine timber was dying on a large estate not far from Idaho Springs, Colo., and in the adjoining Pike National Forest. Mr. Edmonston was then instructed to make more detailed examinations, after which he reported that some 63,000 feet of standing timber on the estate was infested by the Black Hills beetle, and that

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unless the ravages were checked at once it would kill the timber not only on this estate but that on the adjoining estates and national forest. The owner of the property was advised by the Bureau of Entomology to take radical action, but no action was taken before the first of the following July, and therefore not in time to prevent the broods of beetles from swarming from the infested trees and extending their ravages.

In December, 1907, Mr. Edmonston was instructed to make another examination of the timber, when he found that his prediction was being fulfilled, and that instead of 65,000 feet of timber in the old infestation there was nearly four times as much timber involved in the new, or over 250,000 feet. The owner was again notified of the serious character of the outbreak, and further suggestion made that if the logs from the infested trees were converted into lumber and the slabs burned before May, 1908, it would result in the protection of the remaining living timber. Immediate steps were then taken by the owners to carry out the original recommendations. Mr. Edmonston gave instructions to the manager of the estate in locating and marking the infested trees and in the best methods of destroying the beetles; he also marked infested timber on an adjoining estate and on the national forest. Five months later, in May, 1908, Mr. Edmonston reported that the larger clumps of infested trees on the estate had been converted into lumber and the slabs burned, and that the marked trees on the adjoining estate and national forest had been cut and barked. In November, 1908, Mr. Edmonston was instructed to make another inspection of the forest on the estate and surrounding area, and on December 1 he reported:

Nothing could be more satisfactory than the results obtained by the cutting of the infested timber on the estate. Your recommendations and instructions submitted to the owner, and carefully followed by the manager of the estate, have clearly demonstrated that insect infestation can be controlled and at no expense to the owner of the timber involved; in fact, a very satisfactory price was realized, resulting in a net profit, I understand, of $5 per thousand feet b. m. on the 240,000 feet cut. This, of course, does not include the profit of the milling operations, but for the logs sold at the mill, after deducting the expenses of cutting and logging. The sawmill was owned and operated by an Idaho Springs firm, and the manufactured article sold in that town. I spent six days on the estate, November 18 to 23. After a very thorough examination of the timber, I found only three infested trees, isolated individuals, and over a mile from where the large clumps of infested trees were cut. With the exception of those three trees, there is no new infestation on the estate. I also examined the adjoining lands, but no new infestation was observed. The infested trees which I marked in December, 1907, had been cut and barked. On the Pike National Forest, contiguous to the first-mentioned estate, where you will remember I marked some clumps of infested trees, no new infestation was found—not one tree. I found that all the infested trees I marked had been cut and barked. Ranger Kelso had charge of this work, and it has been quite thoroughly done.

This most gratifying result demonstrated two important things; one, that a quite extensive outbreak by one of the *Dendroctonus* beetles, involving near 1,000 trees, can be controlled without expense, and even at a profit, whenever the conditions are favorable for the utilization of the infested timber; the other that the essential details of the recommendations and expert advice based on the results of scientific research can be successfully applied by a manager of a private forest or by the rangers of national and state forests. It also indicates quite conclusively that the widespread depredations in the

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Black Hills Forest Reserve could have been prevented with very little expense to the Government if the matter had received prompt attention in 1901, when the first investigations were made and essentially the same recommendations submitted. But, through the lack of public appreciation of the importance of the problem at the time, and the lack of sufficient authority and funds later, infestation was allowed to extend beyond practical control, and in consequence a large per cent of the timber of the entire national forest has been killed. There were then no forcible examples of the practical value of such recommendations based on scientific research, and no other argument was effective in arousing public interest in the threatening character of the outbreak. Now we have several examples demonstrating the practicability of forest-insect control in America which should lead to confidence in the results of research as a basis for successful practical application.

CONTROL OF HICKORY BARK BEETLE.

The complete control of the hickory bark beetle, whose ravages threatened the total destruction of the hickory trees on Belle Isle Park, at Detroit, Mich., in 1903, was effected by felling and removing the infested trees and converting them into merchantable products, all without cost to the park commission.

CONTROL OF INSECTS WHICH CAUSE DEFECTS IN LIVING TIMBER.

The class of insects which cause defects in the wood of living timber can be controlled to a greater or less extent, depending upon local conditions, and a large per cent of the losses can be prevented through the adoption of certain requisite details in forest management, especially (*a*) the utilization of all of the defective and infested timber that will pay expenses for manufacture into merchantable products, such as lumber, cordwood, etc.; (*b*) the burning of infested timber and waste material not available for use, including dead standing and down timber, to remove the breeding places of insects such as the oak timber worm and the chestnut timber worm, which insects go from the dead timber to the living; (*c*) the prevention of wounds of any kind in the bark of living trees; and finally (*d*) to prevent future losses by the practice of improved forestry methods, which will eliminate favorable conditions for injury and contribute to a perpetual supply of vigorous, healthy timber to be utilized before it passes the stage of profitable increment.

PREVENTION OF INJURY TO DYING AND DEAD TREES.

A large per cent of the injury to insect, fire, and lightning killed trees and trees killed or dying from injuries by storms, disease, etc., can be prevented—

1. By the prompt utilization of such timber within a few weeks or months after it is dead or found to be past recovery;
2. By removing the bark from the merchantable portions of the trunks within a few weeks after the trees are dead;
3. By felling the trees and placing the unbarked logs in water;
4. And, finally, by the adoption of a system of forest management which will provide for the prompt utilization of all trees which die from any cause.

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PREVENTION OF LOSSES FROM INSECT INJURIES TO NATURAL AND ARTIFICIAL REPRODUCTION.

The successful control of insects which destroy or prevent the normal development of natural reproduction is a far more difficult problem than that presented by other classes of insect injuries, but in this, as in the others, a great deal can be accomplished toward preventing the reduction of future supplies.

Much can be accomplished in the nursery and on small plantations by the adoption of the ordinary methods of controlling farm and orchard insects, but in the natural forests reliance must be placed largely on systems of forest management.

UTILIZATION OF IMMUNE AND RESISTANT VARIETIES AND RACES OF TREES.

Certain individuals representing varietal or racial forms of trees of a given species are sometimes found to be either immune or decidedly more resistant to the insects which are destructive or seriously injurious to the life or wood of other individuals or varieties of the same species. This fact suggests the importance of recognizing the well-known principle of improvement by selection. Thus selecting seed or cuttings from such immune and resistant trees for artificial propagation, or taking great pains to leave such trees in commercial or selection cuttings, will undoubtedly be an important step toward providing against damage and losses in the future.

PREVENTION OF INSECT INJURIES TO FOREST PRODUCTS.

CRUDE PRODUCTS.

The problem of artificial control and prevention of insect injuries to forest products offers less difficulties perhaps than that relating to many other branches of the general subject of forest insect control.

In most cases the principle of prevention is the only one to be considered, since the damage is done soon after the insects enter the wood and therefore it can not be repaired by destroying the enemy.

Crude Products.

The degree of moisture found in the bark and wood of newly felled trees, saw logs, telegraph poles, posts, and like material cut in the fall and winter and left on the ground or in close piles during a few weeks or months in the spring and summer, or during the period when the particular species of injurious insects are flying, is one of the conditions most favorable to attack. This period of danger varies with the kind of timber and the time of the year when felled. Those trees felled in late fall and winter will generally remain attractive to ambrosia beetles and the adults of round and flat headed borers during March, April, and May. Those felled during the period between April and September may be attacked in a few days after they are felled, but the period of danger may not extend over more than a few weeks. Thus certain kinds of trees felled during certain seasons may never be attacked, while if felled at other seasons the conditions for attack may be most favorable if

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insects are active, and then the wood will be thickly infested and ruined. The presence of bark is absolutely necessary for successful infestation by most of the wood-boring grubs, because the eggs and young must occupy the inner and outer portions before the latter can enter the wood. Some ambrosia beetles and timber worms will, however, attack barked logs, especially those in close piles or otherwise shaded or protected from rapid drying. A large per cent of the injury to this class of products can be prevented—

1. By providing for as little delay as possible between the felling of the tree and its manufacture into rough products. This is especially necessary with trees felled from April to September in the region north of the Gulf States and from March to November in the Gulf States, while the late fall and winter cuttings should all be worked up by March or April;

2. By removing the round timbers from the woods and skidways during the danger period, or if this is impossible, by taking every precaution to facilitate the rapid drying of the inner bark by keeping the logs off the ground, in the sun, or in loose piles; or else the opposite extreme should be adopted and the logs kept in water;

3. By the removal of the bark from poles, posts, and other material which will not be injured by checking or season cracks, within a few days after the trees are felled;

4. By working in the proper months or seasons to fell or girdle different kinds of trees.

Damage to products cut from saplings and left with the bark on can be prevented by transporting the material from the woods soon after it is cut, so it will not be left in piles or bundles in or near the forest during the season of insect activity, also by frequent change of place of storage.

Pin-hole damage to stave and shingle bolts cut during a warm season can be prevented by removing the bark from the timber as soon as it is felled and by converting the bolts into the smallest practicable dimensions and piling them in such a manner as to facilitate rapid drying.

Damage to unseasoned handle and wagon stock in the rough can be prevented by taking special precautions to provide against the same favorable conditions for attack as mentioned in connection with round timbers. This is especially necessary with hickory and ash if cut during the winter and spring.

Damage to pulp wood and cord wood can be prevented to a great extent by placing the sticks in triangular or crib piles immediately after they are cut from the trees, especially if the timber is cut during the danger period or must be held over a few months during the warm season. Peeling or splitting the wood, or both, before it is piled will also provide against damage from insects.

MANUFACTURED PRODUCTS.

UNSEASONED PRODUCTS.

Freshly sawed hard-wood lumber placed in close piles during warm damp weather, within the period from July to September, inclusive, presents the most favorable conditions for injury by ambrosia beetles. In all cases it is the moist condition and retarded drying of the lum-

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ber which induces attack. Therefore any method which will provide for the rapid drying of the lumber before or after piling will tend to prevent losses. It is important also that heavy lumber should, as far as possible, be cut only in the winter and piled so that it will be well dried out before the middle of March.

The damage to lumber and square timber when the bark is left on the edges or sides can be prevented by removing the bark before or immediately after the lumber is sawed, or by sawing and piling the material during the winter, or if sawn at other times, piling it so as to facilitate rapid drying.

SEASONED PRODUCTS.

Unfinished seasoned products.—Injury by powder-post beetles to dry hard-wood lumber and other material in stacks or storehouses can be prevented—

1. By a general inspection of the material in the yards and storehouses at least once a year, preferably during November or February, for the purpose of sorting out and disposing of any material that shows the slightest evidence of injury, as indicated by the presence of fine powdery boring dust;

2. By preventing the introduction into lumber yards or storehouses of any infested material, remembering that the insect may be thus distributed to all parts of the world;

3. By the adoption of a system of classification of all dry or seasoned hard-wood stock which will provide for (*a*) the separation of the pure heartwood material from the pure and part sapwood material; (*b*) classification of all kinds of wood most liable to attack, such as hickory, ash, oak; (*c*) the successive utilization or sale of the older material (remembering that material one year old or over is far more liable to injury); and (*d*) providing against the accumulation of refuse material in which the insects could breed.

Finished products.—Damage to finished handles, oars, spokes, rims, hubs, wheels, and other unpainted wagon, carriage, machinery, and implement stock in factories, wholesale and retail storehouses, army and navy stores, can be prevented by the adoption of the same general rules as those given under rough products. In addition, damage can be controlled and prevented—(*a*) by sorting out and destroying all articles showing the slightest evidence of powder-post injury, or (*b*) treating with kerosene oil such infested and slightly injured articles as may be tested for required strength and found to be of sufficient value to retain, the same to be placed in quarantine a sufficient length of time to determine whether the treatment is successful.

Damage by insects to many articles can be prevented, and at the same time the material benefited, by treating the wood with linseed oil, either by immersion in the oil or by application with a brush, the application to be made as soon as possible after the articles are finished.

PAST AND PRESENT CONDITIONS OF POWDER-POST INJURY.

Up to 1906 there were a great many reports of extensive losses of valuable material from the extensive ravages of powder-post beetles, which were seriously affecting all industries involved in the manu-

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facture, sale, and utilization of the classes of hard-wood products. In response to these reports and accompanying appeals to the Department of Agriculture for information on causes and remedies, the problem was thoroughly investigated, and specific advice and instructions relating to practical methods of control and prevention have been widely disseminated, both through publications of the department and special correspondence.

Reports of present conditions, with fewer requests for advice, indicate that the disseminated information has been extensively utilized and that it has been worth many millions of dollars toward eliminating the losses and reducing the drain on the limited supply of the kinds of timber required to replenish the damaged and destroyed material.

The army and navy stores of handles, tent poles, wheelbarrows, oars, and many other hard-wood articles have suffered severely from powder-post damage, but the information supplied has contributed greatly toward the elimination of this source of loss to the Government.

TAN BARK.

Damage to hemlock and oak tan bark by the class of insects which in some cases have been so destructive to this class of products in the past can be easily prevented without cost—

1. By utilizing the bark within three years from the time it is taken from the trees;
2. By preventing the accumulation in the yards and store sheds of old waste material in which the insects can breed.

These simple methods have been extensively adopted since their recommendation in correspondence and publications between about 1894 and 1904, and constitute one of the most striking examples of the value of expert information on the peculiar habits of insects and of how millions of dollars can be saved by exercising a little judgment.

UTILIZED PRODUCTS.

Damage and losses from insect injuries to timber and other woodwork in structures of various kinds, to telephone and telegraph poles, posts, railroad ties, mine props, etc., can be prevented by treating the material with preservatives.

TIMBERS AND WOODWORK IN STRUCTURES.

Injuries to timbers and woodwork in dwellings, outbuildings, bridges, etc., by powder-post insects can be prevented—

1. By the use of heartwood only for the concealed parts most liable to be damaged;
2. If it is necessary to use all or part sapwood material, attack can be prevented by treating the sap portions with kerosene, coal tar, creosote, or linseed oil. Facilities for future treatment can be provided wherever the rough or finished woodwork is exposed, as in outbuildings, bridges, etc., if care is taken to expose the sapwood portions;

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3. If the timbers and woodwork in old buildings show evidence of attack, the affected portions should be treated with a liberal application of kerosene.

Damage by white ants or termites can often be prevented—

1. By the use of sound wood only for underpinning and foundation timbers and the removal of decaying timbers from old structures;
2. By preventing abnormal moist conditions of the wood in any part of the structure, and especially of that in foundation timbers;
3. By the treatment with creosote, zinc chloride, corrosive sublimate, etc., of timbers necessarily exposed to moist conditions;
4. If the timbers become infested, further injury can be prevented by removing the badly damaged parts and soaking the remainder with kerosene, fumigating with bisulphide of carbon, and by removing any adjacent wood in which the insects may breed, such as logs, stumps, etc.

LOG CABINS AND RUSTIC WORK.

Damage by bark and wood boring insects to the unbarked logs and poles used in rustic cabins, summer houses, fences, etc., can be largely prevented by cutting the material in October and November and utilizing it at once, or by piling it off the ground or under cover in such a manner as to offer the best facilities for the rapid and thorough drying of the inner bark before the middle of March or the first of April following. If this precaution is not taken and there is evidence that insects are at work, the damage can be checked by injecting bisulphide of carbon through natural or artificial openings in the affected bark and immediately stopping these and other openings with putty or a similar substance.

POLES, POSTS, TIES, MINE PROPS, AND SIMILAR PRODUCTS.

Insect damage to poles, posts, and similar products can be prevented to a greater or less extent by the preservative treatments which have been tested and recommended by the Forest Service. These should be applied before the material is utilized, or if attacked after it has been utilized, further damage can be checked to a certain extent in like manner.

It is of prime importance to prevent injury from wood-boring insects because such injuries contribute to more rapid decay.

UTILIZATION OF NATURAL ENEMIES OF INJURIOUS INSECTS.

Were it not for the natural checks of control of some of the more destructive insect enemies of forest trees and products, successful artificial control would, in many cases, be impossible, and the depredations would be far more complete. These natural enemies of the depredating insects consist of parasitic and predatory insects, diseases of insects, birds, adverse climatic conditions, etc. While one or more of these beneficial factors exerts a continuous and powerful influence toward the prevention of a more extensive waste, it has been repeatedly demonstrated that these checks can not always be depended upon to prevent widespread devastations by protecting the best trees and the best tree species. The insects and birds which prey upon the depredating insects also have enemies consisting of insects, birds, dis-

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eases, and climatic conditions. Therefore under normal conditions the tendency is toward the preservation of a balance between the warring factors, but frequently the enemies of the trees get the ascendency and take the character of an invasion, which may continue for two or three or even ten years before the balance is restored. Thus a vast amount of timber or a given forest product may be destroyed before the factors of natural control can prevail.

It is evident that the most effective utilization of the factors of natural control will be through our assisting in the destruction of the enemy rather than through the artificial introduction of such factors. The former is accomplished by the adoption of methods of combating the invaders which will reduce their forces below the power of attack, or by reducing their numbers to the point where they must occupy a defensive position against their natural enemies and become dependent for their supplies of food and breeding places upon that avoidably furnished through mismanagement of the forests and manufacturing operations. Thus we can contribute greatly toward the preservation of a balance which will be to our material benefit. On the other hand, we may in the future, as we have in the past, contribute greatly to the multiplication of the depredating insects and to greatly increased losses caused by them through ignorance or disregard of the fundamental principle of insect control in the management of forest and manufacturing enterprises.

BENEFICIAL INSECTS.

The beneficial insects comprise those which are internal or external parasites of the immature or matured stages of the injurious insects, also those which feed on the young or adults. These two classes are doubtless far more effective in the long run than any other set of agencies of natural control. Yet they, in combination with all other factors, can not be always relied upon to render the desired service of continued and efficient control. They can, however, be relied upon to respond to artificial assistance in the reducing of the depredators or to proper artificial introduction and distribution.

BENEFICIAL DISEASES OF INSECTS.

It is very evident that the parasitic fungi and bacteria which sometimes cause epidemics among injurious insects often exert a powerful influence toward the control of extensive outbreaks or invasions of insect enemies of forests. Indeed, it appears that the greatest service rendered by this class of natural enemies is in the often sudden appearance of an epidemic which kills off a destructive species of insect, which has increased to such numbers and extended its depredations over such vast areas as to be far beyond the control of man or his insect and bird allies. Numerous examples of this kind of natural control are found in widespread depredations by various species of caterpillars and sawfly larvæ which defoliate deciduous and coniferous trees. As a rule, however, the beneficial effects of the diseases of insects prevail only after the injurious insects have increased to excessive numbers. Therefore this factor of insect control can not be depended upon to hold the insects in check or prevent outbreaks. The fact, however, that it operates on a class of insect enemies of the

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forest (defoliators) which can not be controlled by any known artificial methods renders the services of the diseases all the more valuable.

It is believed that with further knowledge of nature's method of propagating, perpetuating, and disseminating epidemics among insects, they can be utilized more or less successfully through artificial propagation and dissemination to head off threatened invasions by defoliating insects.

BENEFICIAL BIRDS.

That certain classes of birds, such as woodpeckers, render valuable service toward the natural control of certain destructive bark and wood boring insects is very evident. They appear to render the greatest service, however, where but few trees are being killed or injured, because their concentrated work on such trees may contribute toward the prevention of an abnormal increase of the insects. They also render some service as allies of the other beneficial factors which assist in artificial control. It is evident, however, that where many hundreds or thousands of trees are being killed, the comparatively limited number of birds in any forest under the most favorable conditions can have little beneficial effect. Therefore, while the birds should be classed among the valuable friends of the forest and should be protected, it is plain that they can not, even with the utmost protection, always be relied upon to protect the forest against destructive ravages of insects.

We must remember in this connection that there are complicated interrelations between birds, injurious insects, and beneficial insects which do not necessarily operate to the benefit of the forest. In fact, it may sometimes happen to be quite the reverse. Therefore, in order to derive the greatest benefit from the conflict between the birds, the insect enemies of the trees, and the insect friends of the trees, we must utilize our knowledge of the factors which are contributing toward the preservation of a balance, so that whenever the enemies of the forest threaten to get beyond natural control, we may enter the field and through artificial means endeavor to force them back to their normal defensive position.

BENEFICIAL CLIMATIC CONDITIONS.

The benefits to be derived from climatic conditions which are detrimental or destructive to insect enemies of the forest, while sometimes very great, are necessarily unreliable and thus can not be depended upon to assist in artificial control. In fact, the very condition which may contribute to the destruction of one depredator may favor the multiplication of another.

UTILIZATION OF WASTE CAUSED BY INSECTS.

When we come to consider the vast amount of standing timber in the forests of the country which has been injured or killed by insects, and which will go to waste if it is not utilized within a limited period, we realize the importance of removing the insect-infested timber, because in doing so we contribute more, perhaps, than in any

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other way to the reduction of the insects, and thus provide against serious injury in the future, as well as to the maintenance of control.

PRESENT CONDITIONS AND OPPORTUNITIES.

Unfortunately, the examples of management, or rather mismanagement, which are contributing to an increase of waste are far in excess of instances of proper management. This is due in a large part to the conditions that have prevailed in American forests in the past which have rendered it impracticable to adopt improved policies of forest management, but at present it is largely due to a lack of appreciation of the importance of the subject, and of the opportunities to prevent such losses, when it is not only practicable, but possible, to do so, and will at the same time yield large returns on the necessary additional expense. This is especially true in thousands of farmers' woodlots and private holdings in the States east of the Mississippi River, in which from 25 to 90 per cent of all of the serious injury of the past can be prevented in the future with little or no additional expense over that required for ordinary good forest management.

FOREST ENTOMOLOGY, AS APPLIED TO AMERICAN FORESTS.

It is only within the past eleven years that any attempt has been made toward a systematic investigation of the insect enemies of the forest trees and forest products of the entire country. The state of knowledge of the subject previous to that time can be judged by the fact that a number of the most destructive enemies of forest trees are found to be new to science and that nothing whatever was known of the habits and seasonal history of a large number of the more important known species which are common enemies of forest trees and forest products, and that scarcely anything was known in regard to practical methods of controlling the enemies or of preventing losses from their ravages.

PRESENT KNOWLEDGE.

Within the past ten years forest-insect investigations have been conducted by the Bureau of Entomology of the Department of Agriculture in all of the principal forest regions of the United States, which have led to the following results:

RESULTS OF INVESTIGATIONS.

Satisfactory progress has been made toward the attainment of some of the fundamental objects of the investigations, one of which has been the laying of a substantial foundation for forest entomology in this country, on which future progress can be made along the lines of acquiring, disseminating, and applying information of immediate practical value in the protection of our forest resources.

ACQUIRED OR NEW INFORMATION.

The principal insect enemies of the forest and forest products of North America and the general character and extent of their depredations have been determined.

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The more important facts in the life history, habits, and practical methods of control relating to some of the more destructive insects have been determined.

A mass of original data has been collected relating to forest insects in general, including not only those which are destructive or injurious, but those which are beneficial or neutral in their relation to the forest, as represented by a collection of more than a million specimens of insects and their work.

As a direct result of the investigations of forest insects during the past six years, at a cost of less than $53,000, there has been accumulated a reserve fund of information now available through publications, correspondence, and field demonstrations, which, if properly utilized for practical application, would evidently prevent from 10 to 30 per cent of the annual losses at a very small cost.

DISSEMINATED INFORMATION.

In addition to information disseminated to all sections of the country through correspondence, lectures, demonstrations, exhibitions, etc., the published information, based on the results of investigations conducted by the West Virginia Experiment Station and the Bureau of Entomology of the U. S. Department of Agriculture during the past eighteen years is represented by over 1,300 pages, 99 plates, and 340 figures.

NEEDS.

The work that has been done is only a beginning in the vast field of forest entomology. There is need of more systematic work (or so-called pure science) on the different stages of the thousands of species of injurious and beneficial insects involved. This is absolutely necessary in order to have further scientific basis of facts on which to build the structure of complex details necessary to success in practical application in its broadest sense.

There is need of further detailed studies of habits and seasonal histories of the species of injurious and beneficial insects, as well as of the local and other conditions favorable and unfavorable for their multiplication and work.

Further information is desirable on the principal factors of natural control, in order that it may be better utilized to facilitate artificial control.

There is special need of more general information on, and public interest in, the subject of losses from insect depredations on standing timber and timber products, and a better realization of the possibility and practicability of preventing losses.

Looking to this end, there is need of further demonstration and educational work along the lines which will bring the matter to the attention of the man in the woods, sawmill, factory, or trade, who is in direct touch with the local conditions and business methods.

There is a special need of more experts in forest entomology, and there will be an increasing demand for such experts in the future to organize and take charge of insect-control policies in state forests, public parks, the more extensive private or commercial forests, and in extensive manufacturing enterprises, and also to give instructions to

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students in forestry schools and forestry departments in state and other institutions of learning.

The need of trained and experienced experts in forest entomology for all of this class of work can not be too strongly urged. There is, perhaps, no branch of economic or applied science which requires more technical knowledge and practical experience as a basis for proper investigations and authentic instructions and advice than forest entomology, and there is perhaps no other feature in the science and practice of forestry in which advice and application based on insufficient knowledge is so dangerous.

There is quite general recognition of the importance of guarding against contagious diseases, and of consulting a physician in a case of serious illness, and of the necessity of relying on an authorized pharmacist to fill a prescription, and of administering the prescribed treatment according to directions, but it is a notable fact that comparatively few persons, even when deeply interested in preserving the health of the forest, have heretofore recognized the importance of guarding against insect epidemics or of consulting an expert forest entomologist in the case of threatened or existing depredations. It has often happened that when such advice has been sought and received, the treatment was not administered according to the recommendations, but changed to suit the ideas of some one entirely ignorant of the facts and principles on which it was based. Thus not only the accomplishment of the desired results failed, but often contributed to an aggravation of the trouble and increased losses. The determination of the causes of specific troubles affecting the individuals of a given species of forest tree or an injury to a given type of product is just as complicated and requires the same elements of experience, training, and skill as that required for the determination of the cause of a given disease or the character of a given injury affecting man, and it is just as important to know the cause or character of injury in the former as it is in the latter, in order to prescribe the specific treatment which will yield the desired results.

Therefore, in order to make the best progress toward preventing future waste of our forest resources from depredations by insects, every one interested in the subject, and especially those in authority in public and private institutions of investigation and learning, should see to it that the character of instructions to students and of the information given out to the public is not only the best available, but that it is limited to the range of expert knowledge of the subject possessed by the instructor or investigator.

ELEMENTARY AND TECHNICAL KNOWLEDGE OF FOREST ENTOMOLOGY FOR THE FORESTER.

While it may be desirable that every professional forester should have an expert knowledge of forest entomology, it is rarely possible except under certain favorable conditions for him to acquire more than the necessary elementary knowledge, and even this has not been possible under the conditions which have necessarily prevailed in the forest schools and in the practice of forestry in this country, and little or no time has been available for acquiring the necessary information from subsequent study or experience. Therefore this feature in the education of the American forester has been practically neglected.

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PRESENT REQUIREMENTS OF INSTRUCTION.

As long as expert forest entomologists and authentic text-books based on American insects and conditions are not available for giving a complete course in technical and applied forest entomology, the requirements of such a course should be limited to instruction in elementary entomology and elementary principles of applied forest entomology, which will give the necessary foundation for intelligent observations and utilization of available information as required in future practice.

SUMMARY.

There is conclusive evidence that insects have been in the past, and are now, important factors in the waste and reduction of timber supplies, and will continue to be in the future.

They attack perfectly healthy trees of all ages and kill them.

They have killed a large per cent of the best timber over thousands of square miles of heavily forested lands.

They reduce the value of living timber and that of crude, finished, and utilized products.

HOW LOSSES CAN BE PREVENTED.

The results of extensive investigations and of practical applications during recent years have demonstrated that some of the most destructive insect enemies of American forests, and of manufactured and utilized products, can be controlled and serious damage prevented with little or no ultimate cost over that involved in good forest management and business methods.

It is evident that if the information now available through publications of the Department of Agriculture and through direct correspondence with its experts is properly utilized in the future, it will result in the prevention of an equivalent of at least 30 per cent of the estimated annual waste of forest resources caused by insects, and thus contribute greatly to the conservation of forest resources.

This can be accomplished—

(1) By the adoption or adjustment of certain requisite details in forest management, lumbering and manufacturing operations, and in storing, transporting, and utilizing the products which adoption, at the least expense, will bring about the necessary reduction of injurious insects and prevent their future multiplication or destructive work.

(2) By the adoption of policies of control based upon expert technical knowledge or advice relating to the species, habits, life history, and natural enemies of the insects involved, supplemented by knowledge of the proper management, care, and utilization of the forest and its resources, and by practical knowledge and experience relating to local conditions and facilities.

(3) Reliance on technical advice furnished by recognized experts in forest entomology and forestry as a basis for success in practical application by the owner or forester.

(4) Utilization of so-called matured timber, and especially of dense or pure stands of such timber, thus removing one of the favorable conditions for rapid deterioration through attacks by wood-boring

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insects or the death of the timber through the attack of destructive bark-boring or defoliating insects.

(5) As a rule, it is useless to attempt the extermination of an insect enemy of the forest or its products. It is only necessary to reduce and weaken its forces, so that it can not continue an aggressive invasion, but must occupy a defensive position against its own enemies and become dependent upon conditions resulting from avoidable negligence and mismanagement by the owners of the forests and the manufacturers of forest products.

(6) The utilization of a knowledge of the principles of natural control as a means of contributing to the efficiency of artificial control.

(7) Prompt recognition of the first evidences of a destructive outbreak of the principal insect depredators, authentic identification of the species involved, and prompt action in adopting the proper method or methods of control.

While beneficial insects, beneficial birds, and beneficial diseases exert a continuous and powerful influence toward the prevention of a more extensive waste of forest resources, it has been repeatedly demonstrated that they can not always be depended upon to prevent widespread devastations or to otherwise work for the best interests of the private or public owner by protecting the best trees and the best tree species.

The best way to utilize the factors of natural control is to become their allies and assist in the reduction of the enemy, rather than to try to make them our allies through artificial introduction or dissemination.

A large percentage of the timber injured by insects can be utilized which will, at the same time, without additional expense, contribute greatly to the control of insects which cause waste, and also prevent injuries and depredations in the future.

Under past conditions the poor management or neglect of the average forest has contributed to the increase of depredations by insects.

Under present conditions of better management of local forests and the more progressive manufacturing enterprises, considerable is being accomplished toward the reduction of losses, but in the average forest, and the average business enterprise dealing with forest products, present conditions are little better than in the past.

This is largely due to a lack of appreciation of the importance of the subject and failure to realize the opportunity and practicability of preventing a large per cent of the losses.

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CONSERVATIVE TURPENTINING.

By GEO. B. SUDWORTH,
U. S. Forest Service.

NATURE OF NAVAL STORES.

Naval stores, so called, consist of commercial "spirits of turpentine" or turpentine, rosin, and tar. All are derived chiefly from the resin of pines, but may be derived also from that of such related conifers as the spruces (Picea) and the false hemlocks (Pseudotsuga). Pines gave these supplies in the early history of this industry, as they do now in both this and in European countries. Turpentine and rosin constitute the principal and most valuable products known as naval stores. Pine "tar" or "pitch," once the principal product and so extensively used for rendering marine vessels water-tight, plays but a very small part now in naval-stores production. The present term "naval stores" dates from the use of pine tar in the days of wooden and other ships.

REGION PRODUCING NAVAL STORES.

Naval stores are produced now almost entirely in the South Atlantic and Gulf States. Southeastern Virginia, eastern North Carolina, and South Carolina originally yielded this country's naval stores. They are produced now chiefly by Georgia, Florida, Alabama, Mississippi, Louisiana, and eastern Texas, but very little comes from the last-named State. The center of production is in Florida, formerly having long been in Georgia. The seat of greatest production is likely to be next in the region of Louisiana, Mississippi, and Texas, on which, after the exhaustion of Florida's pine forests, production must depend.

SPECIES OF PINES YIELDING NAVAL STORES.

The longleaf pine (Pinus palustris) and Cuban or "slash" pine, which are pitchy, hard-wooded pines, yield the naval stores of our commerce. Practically all of the other native pines are capable of producing naval stores, but they are not now worked. The near future will unquestionably see at least two or three other southern pitch pines added to the list of producing species, as well as one or two species of western pines. It is not likely that the "white" or soft-wooded pines will ever be resorted to as producers of naval stores.

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HOW NAVAL STORES ARE OBTAINED.

GUM SPIRITS OF TURPENTINE AND ROSIN.

Naval stores were first derived by charring or burning the wood of pitch and other pines in rudely constructed pits or kilns. The product then was pitch only, because charring the wood consumed or liberated as waste the volatile turpentine. Naval stores are now produced by distilling the crude resin obtained from living longleaf and slash pines. The principal product, turpentine, is driven off in steam in a simple copper "still," the turpentine being collected with the water after condensation. The residue, cleared of all impurities by straining, is commercial rosin. No other products are yielded.

WOOD SPIRITS OF TURPENTINE.

Various patented processes, which subject the ground or otherwise reduced "fat" wood of longleaf and slash pine stumps, waste logs, and butts to steam or destructive heat applied to or in closed retorts, produce a form of turpentine, which, when refined, has practically the same commercial qualities as that distilled from crude gum or resin.

This means of obtaining turpentine is comparatively new and still subject to considerable improvement. The steam processes have so far produced a purer grade of turpentine than any of the processes which carry distillation to the point of charring the wood. Much of their products require redistillation to obtain a pure grade of turpentine; but they derive, in addition to turpentine, charcoal, and a residue of heavy pine-tar oil mixed with other ingredients not obtained by the steam processes. The charcoal is, however, practically a waste product, because usually it is too far from a market, while as yet there is very little profit derived from the sale of the heavy tar products.

SOURCE OF CRUDE RESIN.

PRELIMINARY DISCUSSION.

It seems probable that much of the production of naval stores will be dependent in the future, as it has been in the immediate past, upon the production of crude resin from living trees.

The utilization of the waste products of lumbering, such as stumps and other "fat" portions of the trees for the production of wood spirits of turpentine, appears likely to be carried at once to a proper degree of strict economical use. But the magnitude of this utilization depends rather upon the enormous lumbering waste of the past than upon that of any system of lumbering now in vogue or likely to be in the future. The supply of dead and down "fat" pine waste obtainable now is considerable, but it is clearly exhaustible within comparatively few years. No such supply can be looked for even in the immediate future, and certainly not in the distant future, both for the reason that the enormous supply of southern pine timber once available is now very largely lumbered out, and because the intensely conservative lumbering of the present and future will leave comparatively little for the wood distilling turpentine plant. The product,

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therefore, of wood spirits of turpentine can be safely put down as a small part of the country's total naval stores product. Production of wood spirits must then depend entirely upon the use of mill waste, and very much shorter stumps than old systems of lumbering are now affording. Mill waste yields approximately only about one-fifth as much turpentine as the heavy "fat" pine waste logs and high stumps which are worked entirely now for wood spirits.

HOW CRUDE RESIN IS OBTAINED.

The first method of obtaining crude resin was to cut a deep pocket or "box" in the base of the tree for the purpose of collecting the resin which flowed from cuts made in the tree's trunk just above the box. New cuts, "streaks," were made, one above another, each week in order to stimulate a fresh flow of resin, which dripped from the edge of the new cut "chip" into the box. The box held about three pints of resin, and at the end of every four weeks this was "dipped" out by means of a thin, flat, spade-like tool called a dipper.

The weekly chipping proceeded from March to September, when the resin would no longer flow readily. Each tree was usually worked, "turpentined," for four or five seasons, when it was abandoned.

At the end of four or five years the aggregate chipping done to each tree was equivalent to cutting off from two to six slabs (three-fourths of an inch to 2 inches deep) from two or three sides of the tree. The breadth of these slabs was from 8 to 12 inches and from 5 to 7 feet in height. Large trees were thus often practically stripped of their outer layers of living or "sap" wood. Moreover, the depth and width of the box was so great as to actually cut away from one-third to two-thirds of the tree's thickness at the base. The trees were thus so weakened that heavy wind storms easily threw them in large numbers. (See fig. 1.)

AREA OF PINE FOREST PRODUCING NAVAL STORES.

Originally the longleaf and slash pine forest, capable of, and in part, yielding the naval stores of this country, included southeastern Virginia, the coastal plain of North Carolina, South Carolina, Georgia, Florida, Mississippi, Louisiana, and the eastern border of Texas. (See figs. 2 and 3.)

But the area now producing naval stores is very much less, being confined practically to the extreme south border counties of Georgia, to Florida, to limited areas in southern Alabama, to Mississippi, to Louisiana, and to a considerably less extent to eastern Texas. Virginia's and the Carolinas' original pine forests, being nearly or quite exhausted, are now practically out of the producing belt, while eastern Texas forests, still largely intact, are really not yet in the producing belt. This is because of a prejudice among Texas timber-land owners against "turpentining" their pine, and also because they fear the added danger of fire to their timber, which must be specially protected in a turpentined forest. Their belief is that working the trees for naval stores reduces the market value and price of the lumber cut from such trees beyond all profit realized from the turpentine operations. The same belief is shared also by some pine-timber

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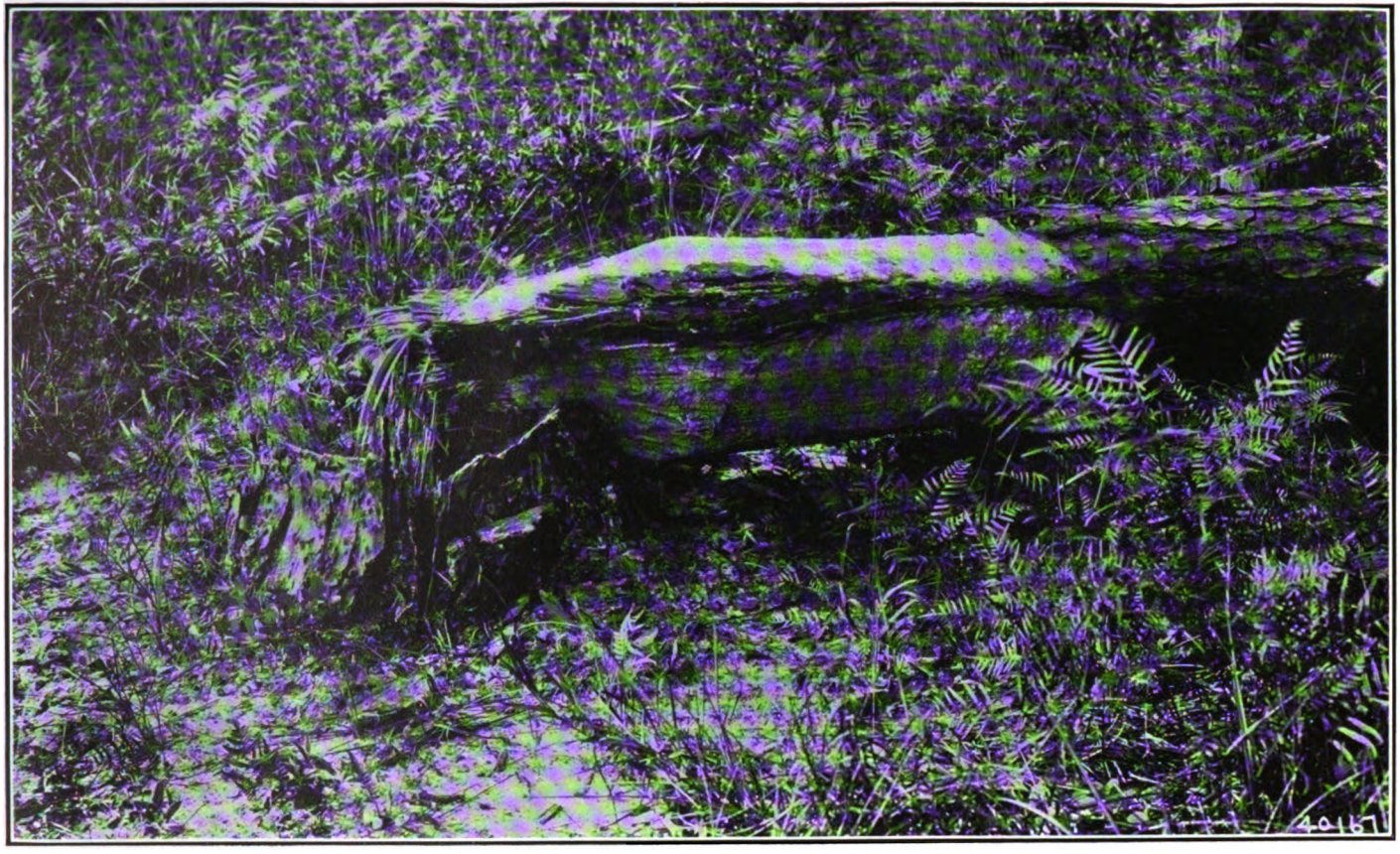

FIG. 1.—FALLEN TREE, TOO MUCH BOXING. NEAR OCILLA, GA.

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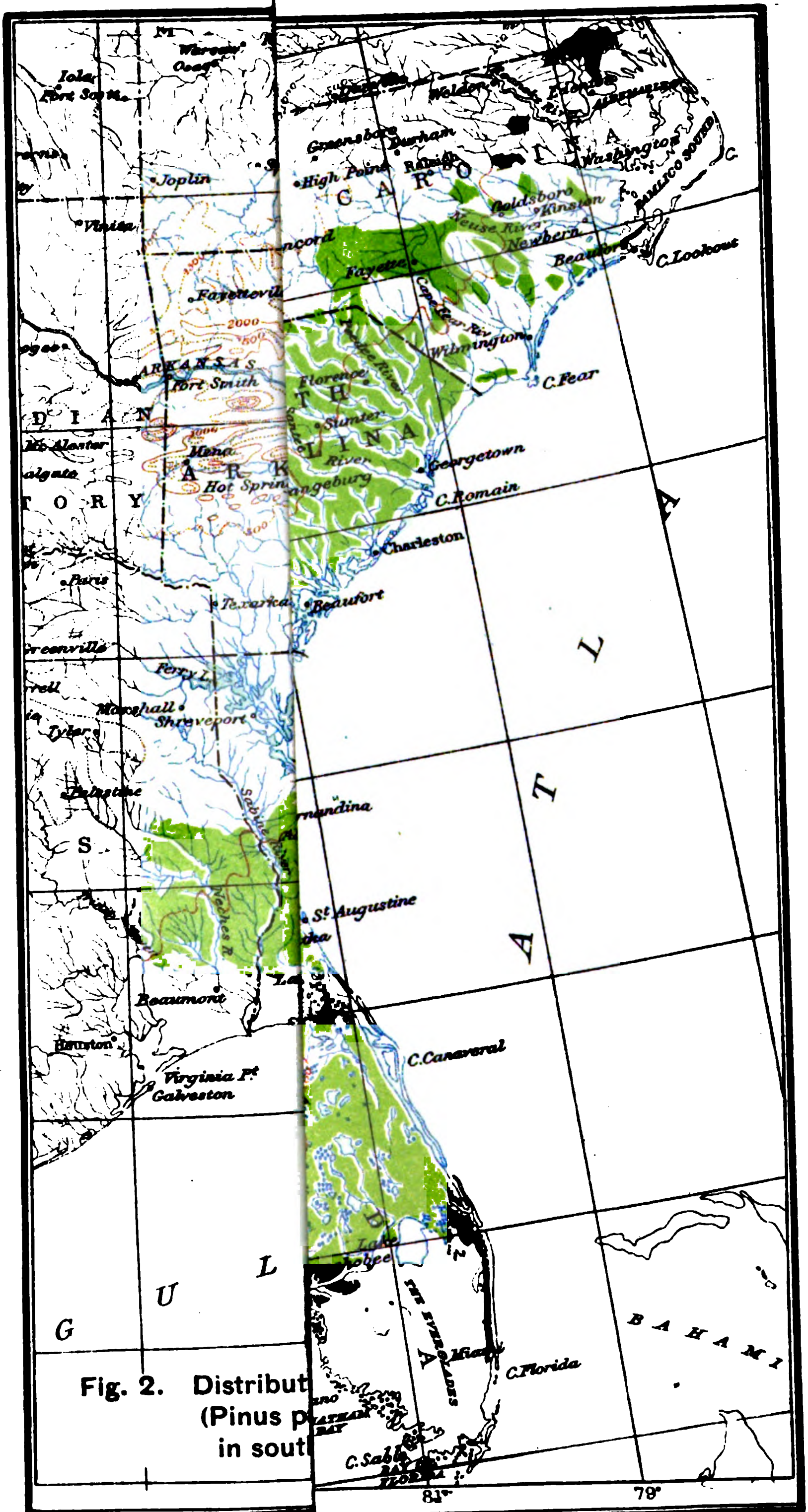

Fig. 2. Distribut
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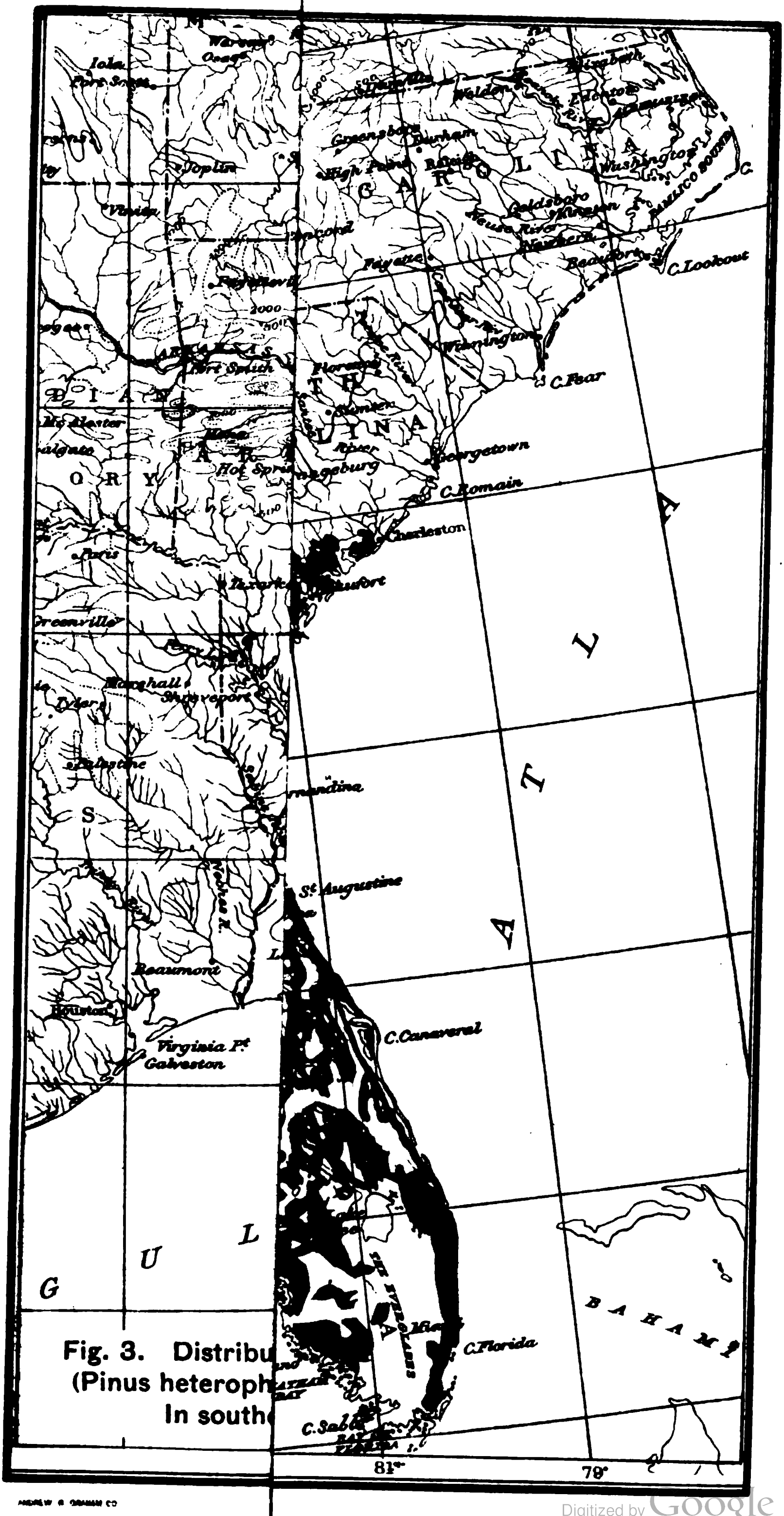

Fig. 3. Distribu
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owners in Louisiana and Mississippi. In the latter States this prejudice has prevented, until within the last five years, the rapid and complete establishment of naval stores production in that region. It is beginning to advance there now, through extensive combined lumbering and naval stores operations, and is likely within the next decade to become fully established throughout the longleaf pine belt.

The still quite general, unrelenting prejudice of Texas pine-timber owners is keeping the longleaf-pine forest of that region out of naval stores production, except in a few localities.

REGION OF GREATEST NAVAL STORES PRODUCTION.

Georgia, Florida, and Alabama, with Florida in the lead, now produce the bulk of our naval stores. Mississippi and Louisiana are next in point of production. Normally these five States, with Texas, should constitute the region of largest production. It is most probable, however, that the center of production, now in Florida, will move westward into the Mississippi River States. With the present generally wasteful methods of working the forests, this movement may take place within the next twenty-five years, or possibly sooner, owing to the present extremely rapid and exhaustive spread of the production in Florida.

CONDITION OF FORESTS PRODUCING NAVAL STORES.

Of the pine forest now yielding or being worked for naval stores 87½ per cent is being worked by the ancient, destructive box system. Twenty per cent of this timber is passing the point of production, while the remaining 80 per cent is at the height of its productiveness and will cease yielding within two years. Of this producing forest 20 per cent has been more or less burned, which means that the total possible production has not only been appreciably reduced, but that as a result of burning the turpentined tree trunks, the commercial quality of lumber available from this timber is also degraded. Charring the chipped or turpentined trunks produces extensive pitchy areas in approximately 8 to 10 per cent of the saw timber. The total loss from this damage is conservatively estimated at 5 per cent. It is believed to amount to from 5 to 10 per cent, for the damage involves 12 to 15 per cent of the best part of every merchantable tree.

It is estimated that 5 per cent of the forest, yielding or being worked for naval stores under the old box system of turpentining, is either dead or thrown down as a direct result of the severe cutting necessitated by this method. (See fig. 1.) This amount may be safely reckoned as total loss, since the scattered and isolated occurrence of areas so affected are not usually reached by lumbering operations before the timber is badly affected by decay and wood-boring insects.

The remaining 12½ per cent of forest yielding naval stores is being worked under an improved system of turpentining known as the "cup and gutter" or "cup and apron" method. No deep box is cut at the base of the trunk, and the turpentined pine trunks are injured only as a result of the season's chipping, which is on the whole as severe as that resorted to under the box system. The timber is, however, not in danger of being thrown by storm, because the trees are not weakened

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by deep boxes at their bases. This type of timber is relatively in thriftier condition than that worked under the box system, because it has received less injury. It is, moreover, as a rule unburned, for the reason that the intrinsic value of the cup and gutter outfit (liable to destruction by fire) compels greater protection against fire than is usually provided in the case of boxed timber.

PHYSICAL EFFECTS OF DIFFERENT METHODS OF TURPENTINING IN THE PAST UPON THE LIFE OF THE FOREST.

ANCIENT BOX SYSTEM.

Timber worked for naval stores under the old box system is more subject (1) to fire, from which may result death, or such injury of vitality that little or no product is yielded afterwards. From the severity of the box cutting large areas may be thrown by wind and be wholly lost; (2) under this system the forest is rendered unproductive of naval stores practically after the fourth year. Three to four years more of production may be added by cutting boxes on unused sides of the trunks ("back boxing"). The more enlightened operators who own their forests, and therefore value them, and expect to utilize the lumber after the first four years' use, for turpentining, refrain from "back boxing" to avoid the certainty of total or very great loss likely to follow from windstorms, which, as already shown, such over-boxed timber is too weak to withstand.

ALL YOUNG, AS WELL AS OLD, TREES ARE TURPENTINED.

In the earlier great abundance of naval stores producing pine timber only large trees were boxed. The young pole trees were left to grow. "Worked-out" timber was then quickly abandoned for new crops of "round" timber everywhere abundant.

The enormously depleted supply of round timber of to-day results in the boxing of practically every tree the land carries, down to 4 or 5 inches in diameter. This, too, frequently includes every tree. Profitable returns can not be expected from timber less than 10 inches in diameter. No young, unimpaired trees remain to form the future forest. The controlling purpose of this shortsighted policy is to strip the land as completely as possible, because in the life of the present operator another crop of naval stores is not expected. Young trees so severely boxed can not recover sufficiently to grow into thrifty, sound timber; they usually die. Possibility of profitable naval stores production in all sections so treated is either wiped out or will be within half a decade.

NEW CUP AND GUTTER SYSTEM.[a]

Timber worked for naval stores under the cup and gutter system, more conservative than the old box method, is—

1. Least subject to destructive fire, even when the usual annual "raking" is omitted. There are no deep boxes containing greater or less quantities of highly inflammable resin close to the ground, which, once fired, makes possible a burrowing fire at the base of the trees.

[a] The writer desires to make clear that the discussion here of the superiority of the cup and gutter system over the box method is not a criticism of other systems of turpentining which employ cups. Investigation of the cup and gutter system was begun some eight years ago as a means of abolishing the

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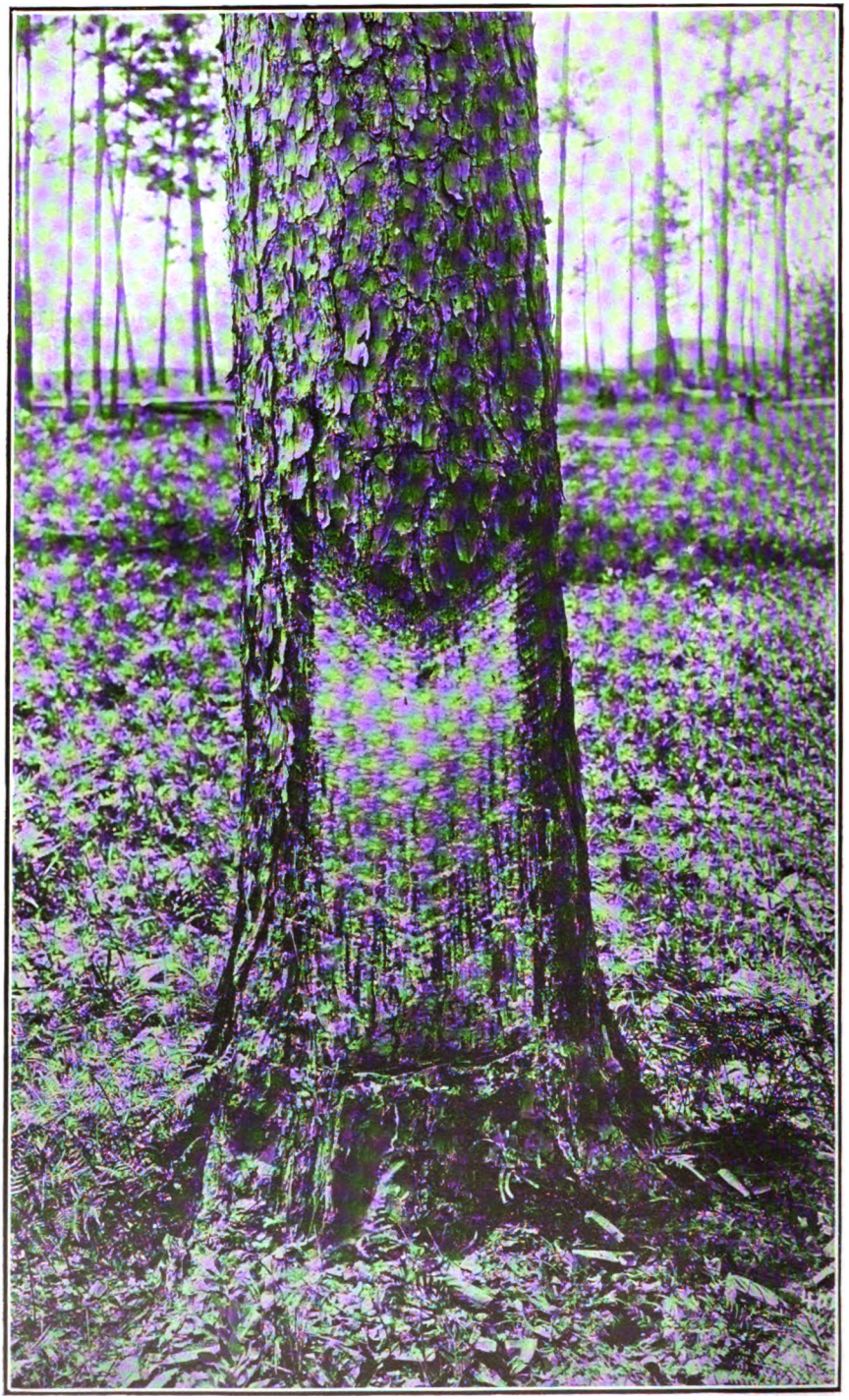

FIG. 4.—FACE OF SECOND YEAR BOXED TREE. NEAR OCILLA, GA.

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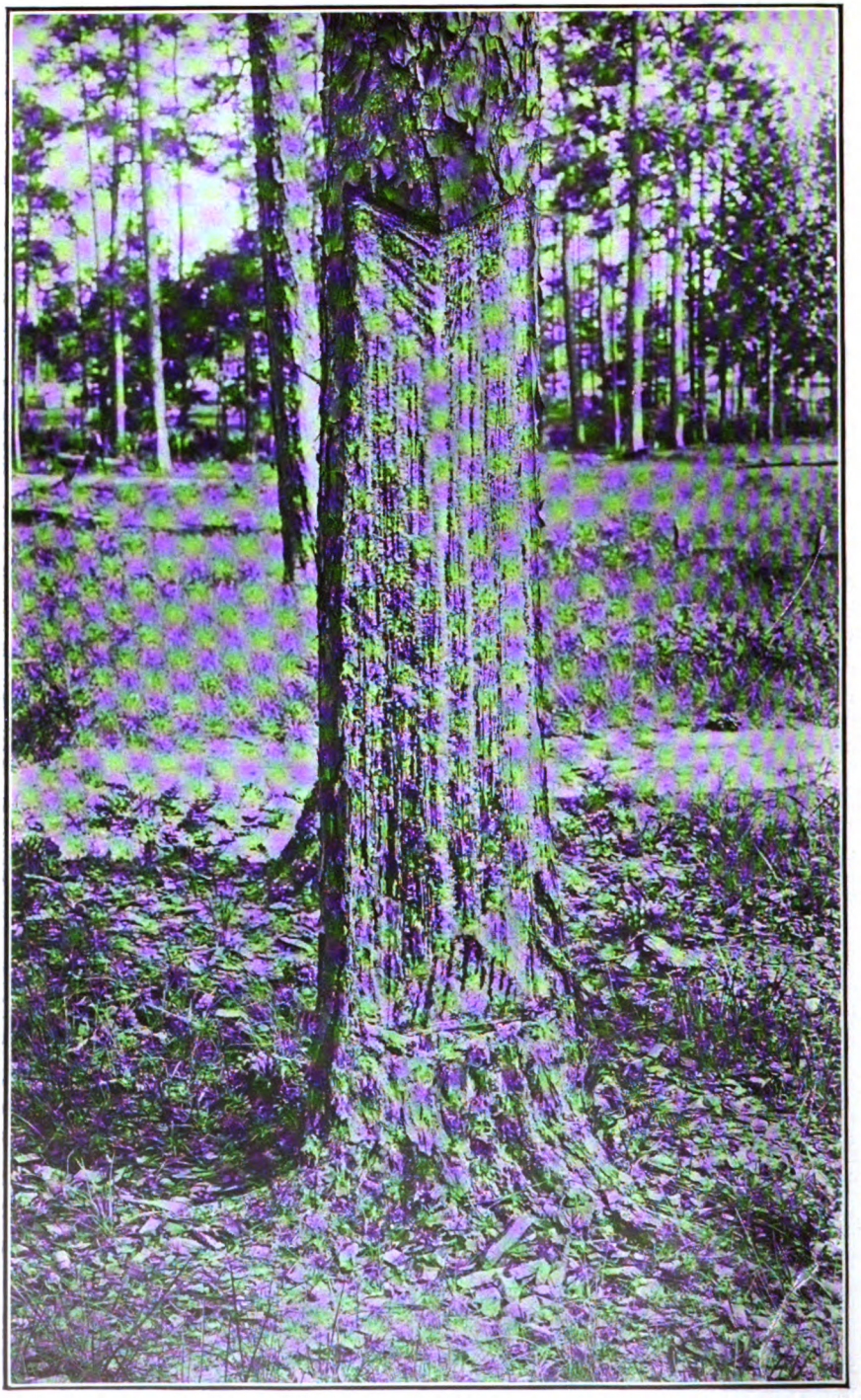

FIG. 5.—FACE OF THIRD YEAR BOXED TREE. NEAR OCILLA, GA.

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2. The trees are not weakened by a deeply cut box, and hence not liable to be windthrown. With only a minimum injury from chipping, trees worked under the cup and gutter system maintain vigorous vitality during the period of production, while afterwards the trees continue to grow thriftily. Even very small trees so worked survive the strain and continue to grow rapidly afterwards.

On the whole pine forests "worked out" in part or completely under the cup and gutter system have undergone much less injury as regards their growing vitality than would have been the case had they been boxed. Ripe timber is in condition to be lumbered without loss by storm, while the younger trees are still in thrifty condition.

LOSS OF POSSIBLE PRODUCT UNDER ANCIENT BOX SYSTEM.

Naval stores production under the ancient system of boxing the trees is carried on at a loss of from 20 to 30 per cent of the possible total product. Moreover, the highest grade of rosin is produced by this method only during the first season.

The loss of product (extending over the four or five years of exploitation) is due (1) to undue evaporation (avoidable under a conservative method) of turpentine by long exposure of the crude resin, which must run farther and farther each season over the chipped face of the trees before reaching the box (see figs. 4 and 5). At the end of the first season the distance traversed by the resin is approximately 15 inches; second season, 30 inches; third season, 45 inches; fourth season, 60 inches. Evaporation is relatively greater each succeeding season, as the resin is exposed to the air for a longer time.

The loss in the quality of the product is measurable only in the grades of commercial rosin produced. Resin gathered from first year or "virgin" boxes yields the highest (whitest) grade of rosin. That gathered from second, third, and fourth year boxes yields lower and lower (darker colored) grades of rosin, which sell for lesser prices than the highest grade.

INCREASED PRODUCTION UNDER NEW CUP AND GUTTER SYSTEM.

The total loss of from 20 to 30 per cent of turpentine under the ancient box system of turpentining is saved by use of the new cup and gutter system. This saving is made possible—

1. By preventing the long exposure to the air of the dripping resin, which each succeeding season traverses a distance of not more than 15 inches of the

destructive box. The superiority of a cup system over the box was demonstrated by the Forest Service with the publication of Bulletin 40 and Circular 34. Since then other cup systems have been devised. The writer has no knowledge, based on actual use, regarding the merits of these systems compared with the cup and gutter system. The important principle of greater conservation of the forest's life and of the turpentine product was clearly demonstrated by the service's use of this particular cup system, and need not be redemonstrated for other cup systems, for the reason that in detailed working, cost of equipment, etc., there does not appear, in the writer's judgment, to be any features of the newer inventions which could increase the advantages, already brought out, of a cup system compared with the box method. For this reason the writer considers the comparative merits of cups and boxes sufficiently settled in so far as the principles of conservation are concerned. Of more immediate importance, as a source of greater conservation for the turpentine industry, has seemed to the writer to be the question of the shallowest chipping possible consistent with the greatest yield of resin.

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tree's chipped face before entering a circular, impervious clay or metal receptacle. This is accomplished by moving the metal gutters (which catch and direct the resin into the receptacle) up to the cup at the end of every season.

Measurable gains in favor of this system also are the facts that less evaporation of spirits occurs from the smaller surface of resin exposed in the circular cup than from the larger surface of resin exposed in the box, and greater economy of crude resin is possible also in gathering ("dipping") resin from circular, smooth cups than from the rough boxes. Much resin is wasted in dipping from boxes, as well as in being imperfectly directed and caught in the boxes, while no resin is wasted when it is being directed into the cups or in collecting from cups. Practically all of the resin yielded by cupped trees is caught.

2. The loss in the quality of rosin made from resin of boxed trees is prevented in the case of cupped trees by causing the resin to run uniformly each season only a short distance into the receptacle. A longer exposure of the resin is found to account for the dark color of inferior rosins obtained from two, three, and four year boxed trees.

POSSIBLE CONSERVATION OF REMAINING FOREST BY USE OF IMPROVED METHOD OF NAVAL STORES PRODUCTION.

HOW LONG NAVAL STORES PRODUCTION WILL CONTINUE UNDER PRESENT METHODS.

It is estimated that naval-stores production would continue, under present methods of exploitation, for twenty-five to thirty years. At that time it is certain that from an industry of the first importance to the South it would sink to an inferior position. This conclusion may be safely founded upon the history of the production in Virginia, North Carolina, and South Carolina (now practically worked out). These States, once heavy producers, have retired from the field of important production, not to enter it again under present methods of exploitation. The States now yielding naval stores are necessarily meeting a much more intensive demand both for naval stores and for lumber (which must, in succession, come from the same forest) than forests of the exhausted States could possibly have been subjected to. It is even probable that present-day methods of exploiting naval-stores forests would bring the end in less than twenty-five years.

ATTITUDE OF NAVAL-STORES OPERATORS TOWARD PERMANENCY OF INDUSTRY.

Present-day naval-stores operators appear generally content to believe that continuance of their industry is coincident with the endurance of southern pine forests. The conviction is fixed that a given forest can be worked only four years, when new (round) timber must be sought for a continuance of operations. The end of this production is clearly conceived to be coincident with that of the virgin forest.

The idea of placing this industry upon a stable, permanent foundation by adopting a more conservative method of operating appears to have been but little thought of. To this end, the idea of adopting the cup and gutter system, a method of exploitation more conservative of the forest's life, in order that operations might not, as under the ancient method, destroy the trees, proved to be a most difficult undertaking for the Forest Service to propagate among operators, so fixed had become the belief that no method except the ancient one could be profitably employed. The accomplishment by the Forest

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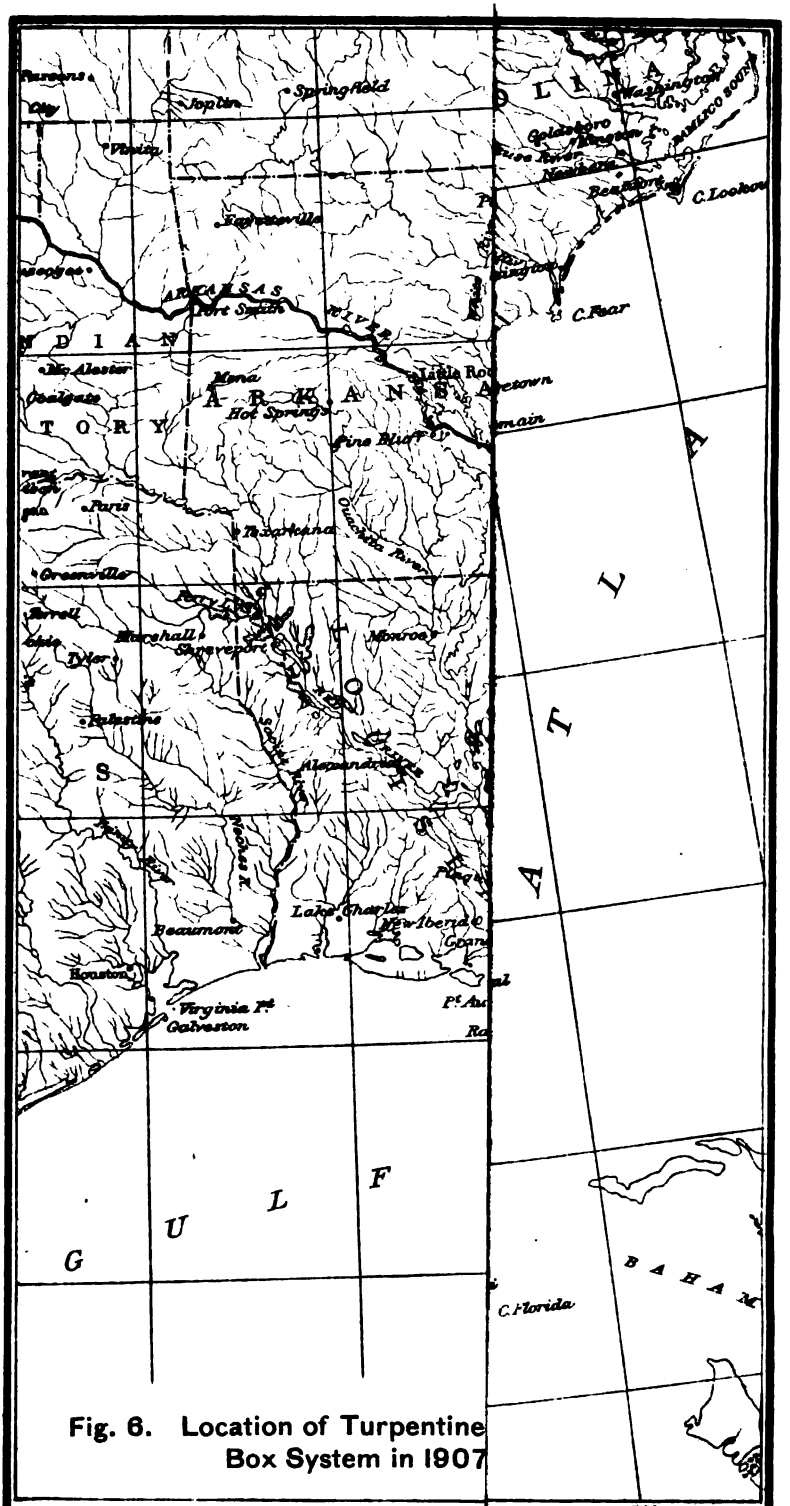

Fig. 6. Location of Turpentine Box System in 1907

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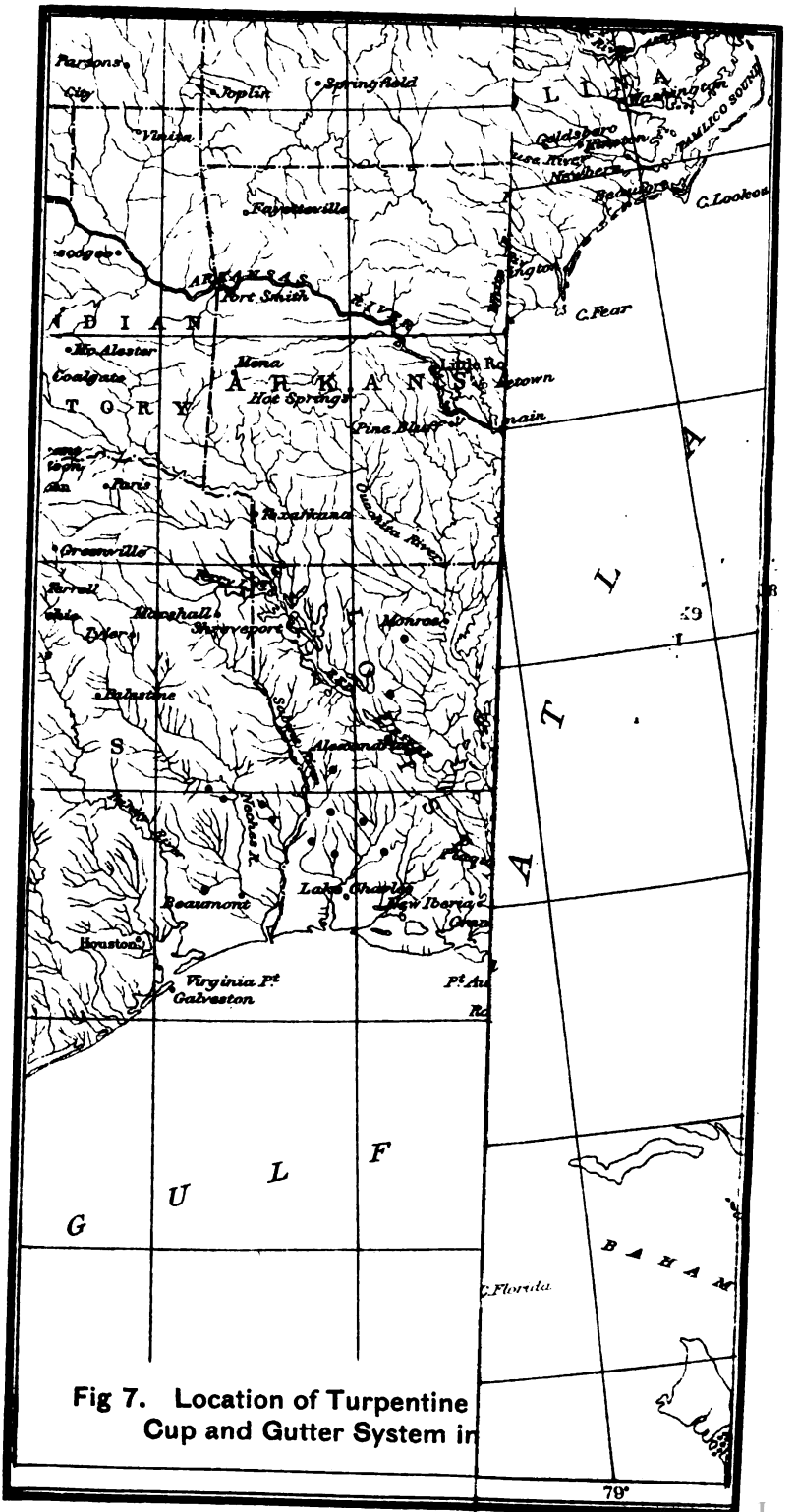

Fig 7. Location of Turpentine Cup and Gutter System in

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Service, through four years of incontestable demonstrative field results, of showing that the cup and gutter system should replace the old box method, was achieved against the deepest sort of prejudice and disinclination among otherwise intelligent operators to accept a new system for the one inherited so long ago. The argument had to be abandoned that, if the new system insured as great a return in naval stores as the old destructive method, it would be to the interest of timber-owning operators to apply this new, conservative method because, not necessitating the cutting of a deep basal box, it injures the trees far less than the ancient system. The idea alone of conserving the life of the forest, of leaving it in as thrifty a condition as possible after naval-stores production, found little or no support. Had it not been possible for the Service to show by actual figures of yield that the new system gives a return of from $1,500 to $1,600 per "crop" (10,000 trees) in place of about $1,000, the old method would still be in universal use, where now some 30,000,000 cups are used. (See figs. 6 and 7.)

Even with this overwhelming proof of what the new conservative method offers in money returns alone, there are many intelligent operators who will not abandon the old system. There is probably not another example to be found in the development of any industry in this country where regional prejudices is so strong against a change of old customs. It is believed, however, that ultimately the idea of maintaining highest conservation in naval-stores production and of placing this industry on a permanent basis can be made to prevail.

Economic conditions are such in the United States that the extremely conservative system of production prevailing in European countries can not be adopted here. The returns accepted there from a naval-stores forest are too small to attract the average American operator. The rate of production and the profit are comparatively much larger here and must needs continue to be in order to satisfy our social conditions. Our past lavish waste in producing naval stores must be reduced to the strictest economy in method of exploitation and in perpetuating, by full use, the life of naval stores producing forests.

WHAT IS ACCOMPLISHED IN CONSERVATIVE NAVAL STORES PRODUCTION AND IN LENGTHENING THE LIFE OF THE FOREST BY A NEW METHOD.

The Forest Service has established by incontestable experiments that the cup and gutter system of deriving naval stores—

1. Yields 30 per cent more product than the ancient method.
2. Does not so weaken the trees physically that they are in danger of being wind thrown.
3. Leaves the timber in thriftier condition because it has not been severely injured by box cutting.

The advantages accruing directly to timber-owning operators are much greater money returns (approximately 50 per cent more than from the old system), and insurance of the timber against destruction by storm before it can be lumbered. The fact that boxing leaves the timber in imminent danger of total destruction by storm has dissuaded not a few pine-timber owners from turpentining their forests at all. Such loss of profit to those people for want of a safe system

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of exploitation can now be obviated by adopting, if not the system shown to be most conservative, the cup and gutter system even with the old method of deep chipping, in place of the destructive box method.

WHAT MAY BE EXPECTED FROM A STILL MORE IMPROVED METHOD OF PRODUCING NAVAL STORES.

A still more conservative method has been discovered by the Forest Service, and its absolute practicability has been thoroughly established by experiments during the last three years on some 80,000 trees.

By this method it is calculated that—

1. A crop of trees may be worked continuously for 15 to 20 years, instead, as at present, of 4 years. At the end of this period the same trees may be worked for another equal term of years, provided the utmost naval-stores capacity of these trees needs to be made use of before lumbering.
2. From 22 to 25 per cent of turpentine (the naval-stores product of greatest value) is obtained in place of from 19 to 20 per cent yielded from present (old and new) methods.
3. The vitality of the trees worked is conserved in the very greatest degree, because the injury from chipping or tapping is reduced to a minimum. Little injury to the trees is a factor in the greater production of turpentine, because the trees being more vigorous, yield a continuously strong flow of crude resin. The greater injury of the trees worked under the older systems weakens their vigor and causes them to yield resin less and less copiously each succeeding year.

This system consists in the use of clay receptacles and metal gutters for collecting the crude resin, and the application of uniformly shallow chipping in place of the generally practiced deep chipping.

DISCUSSION.

The three exceedingly important points of economy in this method are: (1) Greatly increased term of operation; (2) greatly increased product; and, (3) the fullest possible conservation of the growth energy or vitality of the trees.

The high productiveness made possible and the practically indefinitely prolonged operation in one location are the principal factors sought in establishing permanent naval-stores production. Both factors are commercially attractive to the individual operator who must realize profit in his own lifetime. A permanent industry and the greatest conservation of the forest under naval-stores production are also directly effected.

DETAILS OF MOST IMPROVED METHOD.

It is possible now to prolong the working period in the forest without change of base, because the new method requires the cutting away each year of only from 3½ to 4 inches in height of the usable trunk, while in the older systems of chipping or tapping from 15 to 16 inches in height were cut away each season.

It has long been believed by operators that severely deep chipping each week must be resorted to in order to stimulate the fullest flow of crude resin. The Service's experiments have proven, however, that extremely shallow chipping gives the greatest possible flow of crude

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resin, while the crude resin from such shallow chipping yields a larger percentage (approximately 5) of turpentine than does the resin from deeply chipped trees.

DEGREE OF SHALLOW CHIPPING ACCOMPLISHED BY USE OF THE OLD "HACK."

By special training chippers can put very much shallower "streaks" on the trees each week than are commonly cut with the ordinary "turpentine hack." The best possible saving with this tool is something over one year in three, or nearly two years in four, thus extending the usual working period of a forest from four years to six years. Even this shallow chipping was, however, found to be unnecessarily severe. But the limit of perfection is soon reached for this ancient tool because, as in the use of the ordinary chopping ax, control of the cut is dependent entirely upon the personal skill of the chipper, and this can not be made as perfect as is necessary for the fullest economy in chipping.

HOW THE SHALLOWEST CHIPPING IS ACCOMPLISHED BY USE OF A NEWLY INVENTED HACK.

A new turpentine hack has been invented, through directions of Forest Service experts, which affords perfect control of the depth and width of the "streak" cut. The skill of the chipper is not; as in the use of the old hack, a factor in cutting a shallow streak with this tool. A uniformly shallow chip can be taken off, thus making it possible to treat all trees alike and to cut only enough to stimulate each week a full flow of crude resin. Limited experiments indicate that a full yield of crude resin may be obtained by chipping the trees only from three-eighths to one-half of an inch in depth, and in height only from one-eighth to three-sixteenths of an inch. The common practice is to cut a streak from 1 inch to 1½ inches deep and from one-fourth to one-half of an inch high each week.

An important feature of this tool is that, when it is fully perfected, it can be applied to the tree in practically the same manner as the old hack. This will make it unnecessary for chippers to acquire the use of a new instrument—a nearly impossible accomplishment because of deep prejudice among turpentine laborers.

This tool is not in use by turpentine operators, for the reason that, while the working principle of the invention is established, considerable experimentation is required to perfect the detail working of the tool. Moreover, the Service has not yet published the practical results of its study of shallow chipping. The publication and distribution of these results is to take place shortly. With full knowledge then of the special advantages offered by the use of a shallow cutting hack it is moderately certain that the Service's new and highly conservative method of turpentining will be generally accepted.

FURTHER CONSERVATION OF PRODUCT POSSIBLE BY NEW SYSTEM OF GATHERING CRUDE RESIN.

Studies by the Forest Service indicate that from 5 to 6 per cent more turpentine is yielded by crude resin gathered every two weeks than from resin gathered once in four weeks. When gathered once a month, the long exposure to the air results in an appreciable loss

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of turpentine by evaporation. The added expense of more frequent gathering is trivial compared with the percentage of profit gained by the increased yield of turpentine. These studies, only indicative now of probable results, must be carried further before a positive statement of the possible gain can be made.

INCREASED PRODUCT BY CONSISTENT USE OF ALL NAVAL STORES PRODUCING PINES NOT NOW EMPLOYED.

SOUTHERN PINES.

At present only two pines, the longleaf and slash pines, produce this country's naval stores. The Service's study during the past three years of the distinguishing characters of the resins of native pines shows that three more forest-forming pines of the South (loblolly, shortleaf, and Virginia pines) yield naval stores in quantities equal to those of the longleaf and slash pines. Two of these untried species, generally held by operators to be nonproducing, form large forests in the South Atlantic and Gulf States as far west as eastern Texas and northward into Missouri. Their use for this purpose would augment the country's present resources very considerably, and would, in addition, extend the industry into States never before yielding naval stores, and serve also to restore in some measure the industry to States which have ceased producing. It is impossible now to determine what percentage of increase this addition to the resources will add. With the very probable return, by encouraged natural propagation, of these untried pines to areas from which they have been lumbered—unquestionably a wise policy—a still greater naval-stores resource will certainly be added in the future.

WESTERN PINES.

Similar studies by the Forest Service have recently determined that the forest-forming western yellow pine yields naval stores in quality and quantity comparable with the standard longleaf and slash pines of the South. The addition of this tree, which forms extensive forests both in the Rocky Mountain and Pacific Slope States, as a producer will give to western United States a new industry, the value of which can not be adequately estimated. Development of it will require demonstrations by the Forest Service of a special method of tapping the trees and the amount of commercial product obtainable. This is a work distinctly for the Forest Service to undertake on a sufficiently large scale to show what may be expected in that region, which in topography and in the character of its resin-producing pine is so different from the South that the system of turpentining now practiced in the latter region will require special modifications.

FUTURE STABILITY OF NAVAL-STORES INDUSTRY.

Future stability of the naval-stores industry in this country depends upon three factors:

1. Complete application in all naval stores producing forests of the most conservative system of exploitation.

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2. Use throughout the country of all naval stores producing pines.
3. Systematic working of forests for naval stores in coordination with lumbering operations.
4. Effective fire protection.

COMPLETE APPLICATION OF THE MOST CONSERVATIVE SYSTEM OF EXPLOITATION.

Experience of the last half century has shown clearly, in the case of Virginia, the Carolinas, and Georgia, that so wasteful and severely injurious a system of turpentining as the ancient box method results in exhausting the producing forest at such a rapid rate and in such a short period as to preclude all possibility of permanent naval-stores production under that system in any given region. Under such a short-sighted policy and system continuance of the industry is clearly a question, not of established permanent production throughout the regularly maintained forest of the country, as in the case of wheat and other staple productions which become fixed resources of certain sections of the country, but of how long the country as a whole will continue to produce naval stores. Continuance of production is then dependent chiefly upon how long the suitable species of virgin timber of the country will last.

The center of greatest production, beginning at the northeast part of the southern pine forest, has gradually proceeded southward in the Atlantic region to the working limit of this turpentine pine belt. The center of greatest production has, to be sure, gone southward with the development of the southern country, but its progression has been like that of a great and consuming forest fire. A stable industry—a resource—naval-stores production, has not been left along the line of its march. Like the forest fire, it has been transient, flourishing only so long as round virgin timber remained to feed the flames of its turpentine "stills." The timber exhausted—worked out—new stills sprang up farther and farther southward in the great pine belt. New centers of business activity were formed and those in the rear died out. The forest that once gave support is gone or depleted beyond profit for the turpentine operator using the old system. Just as the lumbermen of the Great Lakes pine belt have been forced to go to the untouched forests of the Northwest, so the naval-stores producer of the South has gone farther and farther southward. The Georgia operator is now in Florida, the center of greatest supply, where he is producing heavily. Soon he will be obliged to look westward to the end of the Gulf pine forest.

Production by so wasteful a method that permanency of the industry is impossible, and the end of production can be clearly seen, is inconsistent with the possible permanent development of one of the South's greatest resources.

Use of the most conservative system of turpentining is imperative, therefore, for two reasons:

1. To build up permanent local production wherever a wise forest policy for that section makes it advisable to maintain continuously naval-stores and timber-producing forest.

2. In order to prevent degradation, through the present too rapid exhaustion of existing old forest, of a first-rank industry to a position of unimportance.

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Approximately 20 per cent of the sound timber of the South is still unworked for this purpose. Application to this timber of the latest improved system of turpentining will permit it to be worked for twenty-five to thirty years before lumbering, and will go far toward staying the present rapid and premature exhaustion of a great naval-stores resource. Continued local production, which is greatly needed for the permanent upbuilding of otherwise resourceless sections, will also be encouraged and eventually established.

USE OF ALL NAVAL STORES PRODUCING PINES.

Just as in the sphere of agriculture, there exists, for the sake of the highest economy in production for every region, the necessity of growing as many different kinds of useful crops as possible, so in the field of naval-stores production it is imperative that all producing pines and other conifers be fully exploited for this product. In bringing this about, the most important principle of industrial economy would be fulfilled—the utmost development and utilization of existing resources.

SYSTEMATIC WORKING OF NAVAL-STORES FORESTS IN COORDINATION WITH SUBSEQUENT LUMBER OPERATIONS.

Coordination of naval-stores operations with the lumber operations which follow is looked to but little at present in the exploitation of pine-timber forests capable of yielding two such valuable products. That by careful attention to the proper sequence of rotation of these industries in a given forest the fullest economy in productiveness can be practiced is not to be questioned.

The presence of apparently unlimited timber supplies for pursuing both industries independently has been sufficient justification in the past. Now, however, with greatly decreased supplies of naval-stores forests and enormously increased annual demand for the products of these forests, there is imminent danger of unwarranted waste of the forests' productive energy by inattention to the proper coordination of turpentining and lumbering operations.

A few owners of naval-stores forests are now combining in one continuous operation the production: First, of naval stores; and second, of lumber—the operation intended to strip the land, to make full and final use of the stand. Realization of fuller value from their ownings is the incentive for combining the two industries, just as the great steel manufacturers have come to realize fuller profits by owning and mining the coal they use in making steel. The principle aimed at, but not yet effected, is proper coordination in turpentining and lumbering operations—a combination of effort which is highly essential for practicing the utmost economy and deriving the fullest returns from a naval-stores forest.

Under the ancient method of turpentining much timber has failed of proper utilization for lumber after being worked out for turpentine, because lumbering was not planned to follow at the close of the turpentine work. At the present time many lumbering operations are crowding out, on too short periods of rotation, the production of naval stores or are neglecting it entirely. Both are unjustified in this period of greatest need for utilizing the fullest productiveness of

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forests. No data are available now to show comparatively the ratios of profit in lumbering naval-stores forests and in working them for this industry to the costs of property and of carrying on the two operations. It is believed, however, that relatively much greater returns are realizable from naval-stores operations. Certainly in the fullest economy of use the turpentine forest should be made to produce its fullest returns before ripe portions of the stand are lumbered. This, when properly coordinated with the subsequent lumber operations, will make greatly for the permanence of the industry.

With the accomplishment now of a highly conservative, and at the same time profitable, method of turpentining, all lumbering and naval-stores operations should, for the permanence of both the industries themselves and for the owner's profits, be so carefully coordinated that the lumber interests take up and use the turpentined timber only after it has been made to give its fullest returns of naval stores.

Future studies of the Forest Service are to determine whether or not its extremely conservative method of shallow chipping for turpentine may not be applied to half-grown or to large immature timber without actually checking its profitable annual increment of growth. Should it be possible in this way to work a comparatively young forest for naval stores up to maturity, the long period of naval-stores production sought now during mature life of the forest, will not hold the mature timber out of lumber operations so long beyond the point of mature growth.

EFFECTIVE FIRE PROTECTION.

A word only needs to be said regarding the relation which effective fire protection bears to the permanency of the naval stores industry. Ground fires are the naval-stores operators' greatest and most dreaded enemy. His equipment and "crops" of turpentined trees may be ruined by severe fires. At considerable expense the inflammable trees are protected at the end of every season by raking in a small circle about each tree. Even this does not insure complete protection, for many "crops" are then burned.

The turpentine operator is, therefore, in position to welcome effective state or national fire protective measures. He has come, however, through the apparently impossible enforcement of existing forest-fire laws, to depend upon the protection he himself provides. He prepares, as best he can, to meet the annual ground fires which "irresponsibles" set out. When it can be safely done he burns the grass himself to prevent others from doing it less carefully.

The naval-stores operator would not be inonvenienced if the forest were unburned. Owners of cattle ranged at large in Southern pine forests are charged locally with burning the forests every winter to improve (?) the grass (now only tough sedges which afford little nutrition, as evidenced by the extremely small size of pine-forest cattle).

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CONSERVATIVE LOGGING.

By EARLE N. CLAPP,
Chief of Management, Forest Service.

MANNER IN WHICH MATERIALS ARE USUALLY WASTED.

To one who is familiar with woods work in the United States it is a matter of certain knowledge that in all cases the fullest possible use is not made of the timber cut, and that little thought is given to the question of future supply from areas which are being cut over.

The logging methods which have been used are in all cases the result of conditions. Very naturally a lumberman wishes to operate at a profit, and often he considers the timber supply inexhaustible. In some other cases carelessness and wasteful methods are due to the desire of the lumberman or foreman to avoid conflict with laborers, and very frequently prejudice concerning utilization is responsible for certain classes of waste. The great factors are, however, stumpage and market prices. It is obvious that the percentage of timber wasted in different regions, or even in the same region, and in logging different species, or even the same species, will vary greatly.

Utilization in European countries is much more complete than in the United States, and comparisons when made usually reflect upon operations in the United States. When it is considered, however, that stumpage prices for various kinds of wood in Europe are to-day from two to ten times as great as for the same class of material in the United States, the reason for closer utilization in Europe is obvious. It is decidedly encouraging, however, that utilization in the United States at the present time in some cases is nearly as close as market conditions and stumpage rates will warrant, and such cases are more numerous than ever before.

The reasons for the closer utilization of to-day are clear: Much of the available timber has been cut, and many of the better species, as, for example, eastern white pine, are nearly exhausted, and market prices for the manufactured product are such that the lumberman can well afford to cut low stumps, utilize timber well into the tops, utilize dead timber, and to remove from the woods much more of the merchantable material than formerly.

A casual examination of a cut-over tract gives very little idea of the amount of merchantable material which has actually been wasted. It requires a thorough knowledge of market conditions and a series of actual measurements to determine accurately the percentage of unnecessary waste in any operation.

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MATERIAL LEFT IN THE WOODS.

The most wasteful method of logging is that in which all of the material cut is left in the woods. Cases of this kind have in the past been comparatively frequent, and even at the present time one occasionally sees lumber operations in which little or none of the material cut has been removed. It is not infrequent to find logging operations in which, because of weather conditions, only a partial removal of the timber is possible, and still more frequently it is impossible to remove material cut soon enough to prevent deterioration; for instance, in basswood operations in the North and Northeast, if the logs are left on the ground for a year discoloration of the sapwood follows at least. This reduces greatly the price which may be obtained for the manufactured product by diminishing the amount of lumber of the better grades. This, of course, in cases in which logging is delayed only one year, does not mean an actual loss of material, but loss through failure to utilize to the best possible advantage the material cut. While this kind of loss is exceedingly common, it is difficult to estimate its exact amount.

Heavy snowstorms are frequently responsible for the leaving of large numbers of logs in the woods. Whole skidways are covered and often lost track of, and in many cases it is impossible to return the following spring for logs and skidways which have been left. The fact that the loss in this manner differs frequently in different operations in the same region and under the same conditions shows that in many cases it is more or less due to carelessness. The leaving of lodged trees, while it seems infrequent in the average logging operations, is in reality responsible for a large loss, considering the cut of the whole United States.

In the early days immense tracts of lands in the eastern hardwood belt were cleared for agricultural purposes and the timber destroyed because no markets were available. While this practice is almost a thing of the past, the destruction of all the timber cut from agricultural lands sometimes occurs even to-day. More frequently sawmill men purchase the timber from such tracts at a specified rate per acre and utilize as much of the saw timber at they care for. All the remaining timber is cut and burned, and this in many cases amounts to a considerable waste. There is little excuse for this form of waste under present conditions, since hardwood stumpage for saw timber is now rarely selling for less than $5 per thousand feet b. m., and cordwood stumpage almost universally for $1 per cord.

BAD MANAGEMENT.

Badly managed logging operations are responsible for immense losses, which may include practically all of the classes of waste hereafter discussed. Very frequently the best means of transportation are not used. It is estimated, for instance, that if basswood logs are driven instead of being hauled to the mill by railroad that the loss in the manufactured product, under the most favorable conditions, is at least $2 per thousand. Because of poor management, removal of timber is frequently delayed unnecessarily, so that deterioration to a greater or less extent follows.

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INFLUENCE OF OWNERSHIP.

Another factor which under very similar conditions influences greatly the percentage of waste in logging operations is whether the timber is cut by the owner of the land, the owner of the stumpage only, or under stumpage contracts. Frequently the actual sale of the land with the stumpage may mean careful logging and little unnecessary waste, while the sale of only the stumpage based upon a scale after cutting, or cutting under a stumpage contract, will be followed by very wasteful methods in order that the operator may assure himself of the maximum profits.

LEAVING OF INFERIOR SPECIES.

It has been the exception rather than the rule in the operations of the past for lumbermen to remove more than one or two of the most valuable species of timber from an area in one cutting. Take, for example, the history of logging operations in the Northeast. The first cut removed the white pine and a very few of the largest and best spruce; the second operation followed several years later, removing only the large spruce which was left; after another interval the third operation took out all the softwoods, regardless of size, which were suitable for pulp. In many districts the fourth logging operation is now in progress, and includes the hardwoods left from previous cuttings.

Forest Service Circular No. 118, "Second growth in the Southern Appalachians," gives another instance of first logging the more valuable species from a tract and later returning for other species. It states that many tracts in the Southern Appalachians have been logged at least three times during the last ten years. In the first logging only the poplar and white oak saw timber were taken; the next operation removed the oak timber suitable for staves, and the final logging operation removed the smaller and rougher saw and tie timber of all species. Poorer species still remain on the ground.

Considerable parts of the forests of the United States, particularly of the West, are made up of only two or three species. It is customary in such forests, where there is a great difference in the relative value, to cut only the better species, with perhaps a few of the very best trees of the inferior kind. The species left is so inferior and the stand so scattering that until market conditions and requirements change greatly it will be absolutely impossible to return. The Douglas fir and hemlock stands of the Pacific coast, and lodgepole pine and balsam stands of the Rocky Mountains are familiar examples. In the Douglas-fir forests on the coast it is not uncommon for lumbermen to leave from five to twenty-five thousand feet b. m. of merchantable hemlock to the acre, and this in most cases can not afterwards be logged.

Examples of a similar kind can be given for logging operations in other parts of the United States. While it is realized that logging of this kind is usually the result of actual conditions which would have prevented the removal at a profit of all species at the same time, and that the lumberman was therefore forced to conduct his operations as he did, it can not be denied that the economic waste through

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such methods is enormous. Usually the intervals between logging operations are so long that logging roads have to be reconstructed. It is not customary to follow the same course, and this means that a large amount of timber is cut for building roads. When the best species and the largest trees are removed many of the smaller trees and trees of inferior species are broken, and many more are cut to provide space for skidways and skid roads. The slash which is usually left burns in many cases, and causes great destruction in the timber. One of the greatest losses, and one often least considered, is that of the change in the composition of the forest. If the seed trees of the best species are removed it necessarily follows that the resulting reproduction must be of the inferior kinds.

The results in national forest sales show conclusively that inferior species may be taken in practically all logging operations. In a number of sales on the Manti Forest, in Utah, the total cut is made up of 91 per cent of the valuable Engelmann spruce and 9 per cent of the comparatively valueless white fir. On the Modoc Forest, in California, 5 per cent of the total cut in a number of sales is made up of white fir and 95 per cent of yellow pine. In a number of the sales on the Sequoia Forest, in California, 78 per cent of the total cut is made up of the valuable sugar and yellow pine, while 22 per cent is made up of the inferior white fir and cedar. Purchasers object in some cases to the inclusion of inferior species in sales, and there is more or less difficulty in marketing the product manufactured from such species. Even when inferior species are included, however, purchasers have finally been able to market the product and to compete successfully in the general market with lumbermen who are cutting from privately owned lands and who do not remove inferior species to any great extent.

LEAVING OF SMALL BODIES OF TIMBER.

It is the experience of nearly all lumbermen that small bodies of timber in comparatively inaccessible places are, as a rule, left when the area is cut over. In many cases such bodies of timber could be removed at a slight profit or without actual loss. If small bodies of timber of this kind were removed it would enable lumbermen to hold other accessible timber, and the rise in stumpage prices at the present time is so rapid that the gain would be considerable in most large operations. Generally, when small bodies of inaccessible timber are left it is impossible to go back after logging is completed and the camps are taken out. Contracts for the sale of timber on the national forests provide against this form of waste and require purchasers to remove such bodies of timber, sometimes even at little or no profit, since such removal means an economic gain to the country as a whole. Such features are, however, provided for by just stumpage rates for the whole sale.

ONLY ONE CLASS OF MATERIAL TAKEN.

Lumbering operations in which only one class of material is removed from the forest are not uncommon. In cases where this material is saw timber the waste may not be excessive, but in other operations in which, for instance, only hewn railroad ties are utilized,

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much merchantable timber is necessarily left. Of course stumps can be cut low in most species, but the utilization in the tops is not as a rule complete. The greatest loss when ties are cut is perhaps owing to the fact that only trees of certain size, from about 11 to about 17 inches in diameter, can be taken; in other words, the young and thrifty trees of most species are removed from the stand, while the mature and slowly growing trees are left. These mature trees in many cases will be a partial or entire loss before the area in question can be cut over a second time.

Another illustration of great waste, owing to the utilization of only certain products, is in the shake business of the Sierras. Only the sugar-pine trees which split easily can be taken. This means that many trees, even though felled, must be left. Since only the straight grained, clear part of the trees can be taken, all material in the tops must be wasted. Fortunately, however, this form of waste is largely a thing of the past.

LEAVING OF DEFECTIVE AND DEAD TIMBER.

In the usual logging operation a large number of the trees which are only partially merchantable are not removed. For instance, it is found in many of the sales on the national forests that a considerable percentage of the trees in the stands may contain only one merchantable log, and that this log may be cut and removed at a slight profit or without actual loss. The prejudice against the use of dead timber is also responsible for a large percentage of loss in most lumber operations. Contracts in all sales from the national forests provide that the purchaser shall remove merchantable dead timber. In a number of sales in Utah, which include both dead and living timber, 10 per cent of the total cut was dead timber, and for a number of sales in Colorado and southern Wyoming 20 per cent of the total cut was dead timber. This, of course, is an addition to the large amount of dead timber sold in the sales including only dead timber. It is a matter of great interest that in some forests at the present time 40 per cent of all the timber which is being removed is dead. Defective trees which contain one or more merchantable logs and dead timber, if not removed during the first logging operation, are almost certain to be a total loss.

BEST TREES AND SPECIES USED FOR CONSTRUCTION.

Until the past few years it has been the practice in practically all lumber operations to use the best species of trees, and even the best trees, for various construction purposes, such as camps, road making, etc. In almost all cases poorer trees of the better species and trees of inferior species have been available. It is true that in some cases they are not quite as suitable for construction purposes as the better species and trees, but it is certain that the profit in logging operations in the long run is greater by using poor trees for construction purposes. Specific examples of this class of waste are the use of spruce in the Northeast, where balsam and inferior hardwoods are available; the use of good trees in the Southern pine district, where in almost all cases poor specimens are at hand; the use of lodgepole in the

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Rocky Mountains, where balsam could well be used; and the use of Douglas fir in the West and Northwest, where hemlock is left on the ground in most logging operations.

USE OF SAW TIMBER FOR FUEL.

The market prices for various classes of material in the United States at the present time, even though they may seem good, are not yet high enough to insure the utilization of all classes of material to the best possible advantage; for instance, during the summer of 1908 one concern in the Northwest bought the best grade of Douglas fir flooring logs and worked them into cord wood. The reason for this was that it was cheaper to buy the clear, straight-grained logs which split easily than to buy at reduced prices and cut up the knotty and inferior logs of lower grades. The practice of utilizing valuable saw timber for cord wood has also been quite common in parts of the Rocky Mountains and in the eastern hardwood district.

USE OF BARK ONLY.

It was formerly the practice, in order to obtain the supply of hemlock bark demanded by the markets, to cut hemlock and utilize the bark, leaving the logs to decay. In northern New York, for instance, for a period of from twenty to forty years the demand for saw timber was so slight and the price paid for hemlock timber in particular so low, averaging about $4, that it was impossible to handle the timber at a profit. For the bark, however, there was a good demand and high prices could be obtained. The amount of waste was obviously enormous when it is considered that the amount of saw timber to a cord of bark is about 1,000 feet. The same practice was carried on in the hemlock regions of southern New York and Pennsylvania.

Under present conditions the bark of chestnut oak is more valuable for its tannin than that of hemlock, and occasionally the practice of cutting chestnut oak and utilizing only the bark is followed in the Appalachians. The total amount of timber wasted in this manner is, however, comparatively small.

HIGH STUMPS.

In practically all old lumber operations stumps were cut excessively high, and while present practices are a great improvement, there is still much unnecessary waste. In old cuttings in the East and in those parts of the West in which the forests are made up of small trees, stumps of 7 or 8 feet are not uncommon in winter cuttings. The reason for this is obvious when the expense of shoveling away the snow from the trees is considered. In summer cuttings, stumps 2½ to 4 feet are not uncommon. For this waste there is no good reason. In the Northwest in practically all of the cuttings of the past spring boards were used, and fir and cedar stumps as a result will average at least 5 feet in height. In this region spring boards have, however, been practically done away with, so that fir stumps are now cut to about 3 feet and cedar to 3½ feet. It is perfectly feasible to reduce the height of fir stumps to about 22 inches and that of cedar,

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except in the case of defective trees, to about 30 inches. This makes an average loss of at least 6 inches in each tree cut at the present time, which in the aggregate is enormous.

Every lumberman acknowledges that, except for defects, the best quality of lumber in the whole tree is found in the butt log, and therefore, in addition to the actual quantity of timber which is wasted in cutting high stumps, the quality of timber must also be considered.

Some examples of good results now being obtained are of interest. On the national forests, contracts in the Rocky Mountains and Sierra regions provide for cutting stumps to a maximum height of 18 inches, except in special cases, and further provide that the height shall be less if possible. It is reported that in Michigan, in some of the white pine cuttings, stumps are being cut level with the ground. It is commonly known that black-walnut timber is taken down below the ground level by digging around the tree and cutting the roots.

It is decidedly interesting to note the effect of the contract requirements of national forest sales on operations on private lands. One specific instance in western Montana will serve as an illustration. A company logging on its own lands commonly cut yellow pine stumps between 2 and 3 feet. After purchasing timber from the national forests, however, and cutting the stumps 18 inches and lower when possible, the company in question is now requiring the cutting of low stumps on its own lands.

TOPS.

In many logging operations of the past (but rarely at the present time) it was the common practice to take only clear logs and to leave all the knotty logs of the top on the tract. Gradually, however, as market prices have risen, the diameter limit to which trees can be utilized has decreased, until now in the spruce forests of the Northeast private companies utilize spruce and balsam to about 4 inches diameter. In the pine forests of the South logs are commonly taken to a diameter of 10 or 12 inches. In the lodgepole pine and Engelmann spruce forests of the Rocky Mountains cutting on private lands commonly utilizes tops to 8 inches; in the Sierra forests and Douglas fir forests of the Northwest timber on private lands is not commonly cut to a lower diameter than 15 to 20 inches. The contracts in sales from the national forests of the Rocky Mountain regions commonly require purchasers to utilize timber to 6 or 7 inches for saw timber when the logs obtained may be manufactured into merchantable material. The sales from the Sierra and coast forests require purchasers as a rule to take merchantable material to a diameter of 10 inches. Where there is a market for mining material, however, utilization to 8 inches is required. Trees are used for cord wood to 3 inches.

A source of great waste in logging operations throughout the United States has been the fact that tops below saw timber size have not been made use of. In many cases market conditions are wholly responsible for this. In others, it would be possible to utilize tops to a diameter of 2 or 3, or at most 6 inches for some such purpose as cord wood or the manufacture of charcoal.

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LOG LENGTHS.

In the usual logging operation on private lands little attention is paid by superintendents and foremen to the question of varying the lengths of logs cut. In almost any logged-over area pieces of merchantable material 8 or 10 feet in length may be found, when it is the practice to utilize logs as short as 12 or 14 feet. By properly varying the length of two or more logs all of the timber in most cases might have been saved.

As market prices for lumber increase, foremen and superintendents and owners of stumpage are more and more insisting that log lengths be varied to utilize fully the timber in tops of trees, and that log lengths be varied also in order to obtain the best grade of timber which is cut; for instance, by a proper selection of log lengths bad crooks may be avoided; still another instance is the occurrence of defective places in logs, which may be cut out altogether by a proper selection of lengths, and the amount of merchantable material obtained from the tree as a whole may be often increased by 25 per cent.

The question of cutting logs and lumber into both even and odd lengths has been discussed so frequently that it is unnecessary to go into the subject at this time. If market conditions allowed the cutting of logs into odd lengths, it would be possible to vary log lengths in the woods sufficiently to take much better advantage of defects and crooks, and thus secure the maximum amount of lumber of the best grades. It would also be possible to utilize more merchantable material in the tops.

TRIMMING LENGTHS.

Contracts for the sale of saw timber from the national forests provide in most cases that a certain maximum length shall be allowed for trimming. In logs of less than 30 inches in diameter 2 or 3 inches is usually a sufficient length for trimming; above 30 inches from 4 to 6 inches may be necessary. These figures apply to ordinary conditions, and in cases where logs are to be driven long distances in bad streams, it is frequently necessary to allow greater lengths. From 4 to 6 inches should, however, be sufficient for small timber even in very bad streams.

Some firms allow trimming lengths of from 8 inches to over a foot. This means that over 5 per cent of every 16-foot board is wasted in trimming at the mill. It is, however, difficult to estimate in private operations the average loss per log through excessive lengths for trimming, but it is common knowledge that in most cases lumbermen are careless in checking this waste. It is certainly very conservative to estimate the unnecessary length on all saw logs cut as from 3 to 4 inches.

SHORT LENGTHS.

In most regions common usage, present forms of machinery, and popular prejudice are responsible for the nonutilization of short lengths of logs. In the Rocky Mountains logs are rarely cut shorter than 12 feet, and in most operations lengths of 14 and 16 feet are preferred. In the Northwest 16 feet is considered a very short length and longer lengths are preferred. In the Sierras 14 feet is the minimum length, while 16 and 18 feet are the shortest lengths

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to which logs are cut in most operations. In the Southwest logs in a few operations are cut to a minimum length of 12 feet, while in rare cases lumbermen may cut to 10 feet; as in the Rocky Mountains, however, 14 and 16 feet are the common minimum lengths. In the pine forests of the South a minimum length of 10 feet is unusual, and logs are commonly cut 12 feet or more. In the hard-wood forests, with the exception of hickory, pulp material, mine props, and stave and heading blocks, logs are not cut below 8 feet in length.

In the Adirondacks 4-foot pieces are now used for pulp, and in New England spruce for pulp is frequently cut to 10 feet.

The following gives an idea of the minimum lengths of timber of various grades and the lengths which can be utilized for various purposes. These data indicate at least that log lengths could be reduced considerably for many species:

Cypress.—Tank, clear, select, shop, 10 to 20 feet; shorts in clear and selects, 12 inches to 8 feet; finishing, 10 to 20 feet; flooring, ceiling, drop siding, molded casing, and base or short lengths, 10 to 20 and 4 to 8 feet; turning stock, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 42, and 48 inches; common lumber, 10 to 20 feet; pickets, 2 to 4 feet; car siding, 8 and 10 feet; car roofing, 5 and 6 feet.

Bay poplar (Tupelo).—Flooring or ceiling, 6 to 20 feet; bevel sidings, 10 to 20 feet; drop siding, 10 to 20 feet; box boards, 12 to 16 feet; clears, 10 to 20 feet; No. 1 common, 6 to 20 feet; No. 2 common, 4 to 20 feet.

Douglas fir (coast).—Flooring—vertical grain, 6 to 16 feet; flooring—flat grain, 10 to 16 feet; ceiling, 10 to 16 feet; partition, 6 to 16 feet; porch decking and ceiling, 4 to 16 feet; drop siding and rustic, 10 to 16 feet; stepping, 6 to 16 feet; finishing, 6 to 16 feet; windmill stock, 10 to 40 feet; battens, 8, 16, 18, and 20 feet; common boards, 6 to 20 feet; joist and scantling, 6 to 32 feet; bridge stringers, 32 feet and under; car sills, 34, 35, 40, 41, 45, 46, and 50 feet; timbers, 32, 44, 51, 55, 56, and 60 feet.

Spruce (coast).—Finish, 6 to 16 feet; thin finish, 6 feet and up; flooring and ceiling, 10 to 16 feet; wainscoting, 4 to 6 feet.

Southern yellow pine.—Common boards, 10 to 20 feet; fencing, 10 to 20 feet; dimension, 10 to 20 feet; heavy joists, 10 to 24 feet; timber, 10 to 32 feet.

Redwood, 3 to 5, 6 to 9, and 10 to 20 feet.

White ash.—Poles, 12 feet long; handles, 38 inches long.

Ash.—Scythe snaths, 5½ feet long.

Elm.—Sleigh runners, 16 feet long.

Fir (Douglas).—Bobsleds, 12 feet; grain tanks, 18 feet long; hay stackers and sweeps, 18 feet.

Hickory.—Axles 12 inches, bolsters 6 inches, bolster stakes 20 inches, doubletrees 52 inches, eveners 4 feet, handles 42 inches, butts 42 inches long, neckyokes 50 inches long, oxbows 5½ feet, singletrees 38 inches, spokes 30 inches long.

Maple.—Axles 6 feet long, bobsleds 4 to 8 inches and 7 feet, harrows 14 feet, sleigh beams 4 feet long.

Oak (white or red).—Bolsters 6 inches, poles 12 feet long, reaches 12 inches.

Oak (red).—Bottom cleats 9 inches, brake woods 6 feet.

Oak (white).—Bolsters 6 inches, bottom cleats 4 feet 9 inches, plow beams 7 feet long, plow and cultivator handles 60 inches, plow standards 28 inches, poles 12 feet, reaches 16 inches, sand boards 2 inches, spokes 30 inches long, tongues 12 feet long.

Pecan.—Oxbows 5 feet long.

Pine (longleaf yellow).—Poles 12 feet, pole (stock grade) 16 feet, harrow eveners 17 feet, hayloader parts 16 feet.

Pine (long and short leaf yellow).—Stub tongue 12 feet.

Poplar.—Wagon box boards 16 feet.

BREAKAGE.

The amount of breakage in felling varies greatly in different operations in the same region and with different species. Much of course

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depends upon the roughness of the ground and sometimes also on weather conditions; as, for instance, in very cold weather the breakage of many species is materially increased. Carelessness is responsible for quite a large portion of loss through breakage. Here again the position taken by the logging foreman may materially increase or decrease the amount of loss, and much depends upon the experience of the men actually engaged in the work. In some operations there is a considerable percentage of loss through improper notching of trees which are to be felled and the splintering which follows. The damage which is done to young growth through careless felling is probably least often considered, and it is certain that the damage to future crops from this cause is very great. No other result can, however, be expected when so few lumbermen are cutting with a view to a second crop.

In logging operations in which it is necessary to use chutes the breakage is often considerable from poorly constructed or poorly operated chutes.

AXES V. SAWS.

In practically all of the lumbering operations of the present time the saw has displaced the ax for felling and cutting. Formerly, however, it was the practice to use the ax almost altogether. In cordwood operations the use of the ax is still common, and the resulting loss is just as great, if not greater, than in a saw-timber operation, because cordwood is cut into shorter lengths.

DONKEY ENGINES.

In some parts of the West the destruction of quite a large percentage of the timber which is left may be attributed to the use of donkey engines in logging. Wire chokers are slung on young trees, which are usually so badly damaged as to be worthless. Many other trees which are left are seriously barked by the use of cables, and drag ways are selected with no thought for the protection of reproduction.

DAMAGE IN SKIDDING AND HAULING.

While it does not decrease the amount of merchantable timber in a logging operation, the damage to young trees through barking in the skidding or hauling operation must be considered because of its relation to future cuts. Such wounds, if serious, result in killing a tree altogether, or in other cases allow infection by fungi, so that before a second operation the tree becomes partially or wholly worthless.

LOSS IN DRIVING.

Although the use of logging railroads is fast taking the place of driving, in some parts of the North and Northwest the drive is still common. In logging operations, which include only spruce, 1 per cent of the amount driven may be considered a legitimate loss. In operations which include pine, either the white pine or Norway pine of the North or the southern pine, 10 per cent on the average may be considered a legitimate loss. In driving, of course, much depends upon the age and quality of the timber; for instance, old timber

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floats much better than young timber in which the amount of sapwood is proportionately large; defective timber becomes water-soaked much quicker than that which is sound, and the loss is, therefore, correspondingly greater. The surveyor-general of the second district in Minnesota, in which district 90 per cent of the timber cut is driven, estimates that 5 per cent of large white pine is lost in driving; that an average of 10 per cent of small white pine and spruce and large Norway is lost, and that the loss in tamarack, balsam, and small Norway will average 15 per cent. The use of logging railroads obviously does away with all loss which results through driving. Another kind of loss must, however, be considered—that of the use of ties. Ties used in logging operations are rarely removed, even though they are sound when the steel is taken up. It is true that many of the ties used in such an operation are made from inferior trees, or inferior species of trees, but, on the other hand, it is very common to use for ties many of the young and thrifty growing trees which might be left to good advantage to form the basis for a second cut.

INDIRECT LOSS THROUGH FIRE.

Practically all of the lumbermen of to-day are cutting in such a way as to obtain a maximum present profit, and are not considering conservative forest management or even a second cut. It is natural therefore that all slash and débris should be left without consideration of protection of the cut-over area. Upon such cut-over lands it is quite certain in most regions that fire will follow. This fire in addition to destroying the slash destroys the greater part of the merchantable timber left, practically all of the young and thrifty growing timber which has escaped the lumbering operations, and what is worse, destroys practically all of the reproduction and in many cases seriously damages the soil itself. Many years must elapse before such fires are followed by even scattering seed trees and, in extreme cases, it is certain that several hundred years will pass before the soil is in any condition to produce even an average crop.

The proportion of cut-over lands upon which fire follows logging operations varies considerably with the species involved. In the eastern white pine belt practically all of the cut-over lands are burned over sooner or later. Upon the greater part of such lands reproduction of the valuable species at the present time is coming in very slowly, because of the comparatively small number of seed trees which have escaped. In the spruce belt of the Northeast, it is estimated that approximately 25 per cent of the lands cut over for saw timber and 50 per cent of the lands cut over for pulp have afterwards been burned over. In the southern pine belt fire follows cutting in almost every instance. The damage to the remaining trees is not, however, so great as in the North and Northeast, and even reproduction, after it has reached a height of from 3 to 10 feet, usually escapes.

In the coniferous forests of the Rocky Mountains and the west coast fire also follows cutting in almost every instance, and the damage in such forests is usually very great, sometimes killing practically all of the trees which have been left in the lumbering operations. In the hardwood regions fire probably follows lumbering much less frequently than in coniferous forests.

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While the damage from fire on cut-over areas is only an indirect result of logging operations, the amount is almost beyond comprehension. As has been stated, fire not only destroys the trees and reproduction which have been left, but also seriously damages in many cases the soil itself. As a general rule, such fires extend beyond the cut-over areas and do a great amount of damage to virgin forests.

INDIRECT LOSS THROUGH WINDFALL.

In some parts of the country the damage through windfall which follows lumbering operations is serious enough to be considered. In New England it is estimated in some cases that such injury, when the cutting has been very heavy, exceeds that done by fire. In other parts of the United States the damage through windfall may consist only of the blowing down of isolated trees and the loss may be comparatively small. Trees blown down in this manner are usually a total loss, since cutting operations have usually been so heavy that it will not be possible to return for a second cut before the windthrown tree has become unmerchantable.

It is the custom in some parts of the United States to transport logs a part of the distance to the mill from the cutting area by rolling them down steep slopes. This practice, while it is very local and relatively of small importance, results in the destruction of practically all of the trees and reproduction in narrow strips.

REPRODUCTION AND FUTURE CROPS.

Since the lumberman is not, except in special cases, considering conservative forest management or even a second cutting, it is natural that he should not insist upon protection of the trees which are left and of reproduction. Reproduction in most cases suffers in almost every phase of the logging operation. The tree is felled, skidded, and hauled regardless of the number of young and thrifty trees which will be damaged. Young and thrifty trees of the valuable species are cut for various kinds of construction purposes, when inferior trees or dead timber are just as available and could be used at a slightly increased cost or at a slight disadvantage. It is exceedingly difficult, if not altogether impossible, to estimate the loss to future cuts through disregard of young growth. Indirectly the ultimate loss may be arrived at through the longer time required to produce a second cut. When, in addition to the direct damage to young growth in logging, fire follows as a result of the slash left, the result is much more serious. Under conservative methods a second cut in, for instance, the Northeast could be provided for within fifty years. If, however, the protection of reproduction is disregarded and fire follows a lumbering operation, it may be necessary to wait two hundred to three hundred years or even much longer to obtain a second crop.

Although the actual present loss of reproduction from any area seems of small importance, the economic loss in such cases probably far outweighs the loss through the other forms of wasteful methods already discussed.

The practice of cutting valuable species and leaving the inferior species for seed trees upon an area is also decidedly objectionable

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when the future crop is considered. Such practice makes it certain that the second crop of timber will be made up chiefly of inferior species, with only a small proportion of the more valuable species which form the present stand.

In the Rocky Mountains and in some parts of the Sierra and coast regions a very heavy cut and the destruction of existing reproduction sometimes result in a stand of chapparal in which it will be exceedingly difficult to bring about forest reproduction. In other parts of the West where reproduction is very light, it is probable that parks will be formed, and in many cases that the existing parks will be enlarged through the removal of too great a portion of the stand and the destruction of reproduction. The grazing upon such parks will, of course, be valuable, but present conditions indicate that the demand for and profit in timber will be greater than the demand and profit for grazing lands.

When we consider the fact that through the careless methods of to-day we are either delaying second and future crops of timber and providing for crops of inferior trees, or perhaps destroying almost all chance for future timber growth, the importance of carefully protecting all young growth is most clear.

Because of the comparatively high prices for lumber, the operator of to-day is in many cases removing trees of small diameter which are just about entering the period of best growth.

Data collected by the Forest Service show that with all species and with all market conditions there is a definite diameter limit, varying in each case with conditions, below which trees can not be cut and removed at a profit.

The following table from Forest Service Bulletin No. 73 shows the actual value of the material cut from yellow poplar trees of various diameters. The data were obtained in mill-scale studies which took account of both quality and quantity of the material produced. In the region in which the studies were made the cost of the logging was approximately $15 per thousand feet, board measure, and accordingly trees smaller than 19 inches in diameter could be logged only at a loss. On trees of 19 inches in diameter the profit, which increased rapidly for larger sizes, was only 34 cents for the thousand feet:

Values of yellow poplar—Virginia, 1905.

Diameter breast-high.	Amount sawed out.	Value per tree.	Value per thousand board feet.	Diameter breast-high.	Amount sawed out.	Value per tree.	Value per thousand feet.
Inches.	*Board ft.*			*Inches.*	*Board ft.*		
13	104	$1.38	$13.27	23	590	$10.61	$17.98
15	171	2.31	13.51	25	761	14.90	19.58
17	246	3.43	13.94	27	948	19.80	20.89
19	341	5.23	15.34	29	1,170	26.22	22.41
21	455	7.53	16.55	31	1,386	32.74	23.62

II. LOSS IN GIVEN OPERATIONS.

Very little data to show the actual amount of material unnecessarily wasted have been collected, some of which are incomplete and do not apply to the conditions of to-day. Practically all of

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the data given have been collected by members of the Forest Service. In each case these data show not the total waste, but the material which under existing conditions could have been utilized, that is, the unnecessary waste. As previously stated, perhaps the most important part of the waste—the destruction to young growth—can be estimated in the difference of time required to obtain second and future crops under the usual and conservative logging methods.

LOGS.

The following data collected in the year 1899, taken from Forest Service Bulletin No. 26, show the waste in spruce saw-timber logging:

(1) Percentage of entire cut wasted through the cutting of needlessly high stumps, 2.

For every 100,000 standards cut 2,000 standards were wasted because of needlessly high stumps. On a tract of 100,000 acres, with an average stand of 15 standards to the acre, the stumpage valued at 40 cents, the actual loss according to these measurements would have been $12,000.

(2) Unnecessary loss through leaving tops which might have been utilized, 6½ per cent of the total cut. It is estimated, however, that the actual value of the material wasted in tops averages only one-fourth as much as that left in high stumps.

(3) Unnecessary loss in building skidways which were not afterwards removed, about one-fourth standard per acre, or 1½ per cent of the total cut in a stand of 15 standards to the acre.

(4) Loss in building roads not estimated, since trees generally used were small and not merchantable under existing market conditions.

(5) The injury done in skidding was mostly to young growth, unmerchantable under existing market conditions, and an estimate was therefore impossible.

(6) Injury done in hauling included the cutting of spruce on steep hills. Although trees of all sizes were cut, the greater part were so small that an estimate of the waste could not be made.

Thus making a total loss of 11 per cent, as follows: (1) 2 per cent; (2) 2 per cent, 6½ per cent, and 1½ per cent; (3) 1½ per cent; (4), (5), and (6), taken together, 1 per cent.

This estimate does not include the sound logs left in the woods and lodged trees which were not felled.

The following data taken from the Forest Service Bulletin No. 30 show the difference in the amount of material obtained when cutting is done by ax or saw. The tree taken, if cut with the saw, would yield 1.26 standards; if, on the other hand, it were cut with the ax it would yield 1.19 standards, making a loss of 0.07 of a standard by using the ax. This loss is equal to one-half of 1 per cent of the total amount obtained by using the saw.

The following data are taken from the Department of Agriculture Yearbook for 1905: "Waste in logging southern yellow pine." The timber in this case was cut by a lumber company which had bought the timber from a land company, with the provision that payment be made upon the basis of the scale of the timber actually removed.

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These measurements were taken in the year 1904, and are a fair indication of the amount of waste in southern pine operations at that time. All the measurements given were taken after logging apparatus had been removed from the cut-over land, so that there was no possibility of returning for the timber left. Measurements covering 300 acres show that more than 6 per cent of the large trees left standing after logging was completed was defective, which in all cases contained one or more good logs. Further measurements showed that of a total number of small and thrifty trees which were considered unmerchantable because of their size (trees below 17 inches at the stump) and were therefore left, 25 per cent was broken, knocked down, or in some way incapacitated for further growth, due almost entirely to careless logging methods. Of the total number of sap trees destroyed by logging it was found by actual count that one-fifth were cut for skid poles. In a stand which would average 10,000 feet b. m. to the acre of merchantable timber the amount of waste in tops per acre was 667 feet and the amount of unnecessary waste in stumps averaged 218 feet. Eight and eight-tenths per cent therefore of the total stand was unnecessarily wasted in tops and stumps. In addition it is estimated that in the ways indicated above 13 per cent of the total cut was wasted in merchantable trees left uncut and in merchantable material cut and left.

The following data taken from the report of the forestry commission of Maine for the year 1896 show the waste in cutting saw timber and pulp. The Maine rule was used in taking the necessary measurements, except as indicated.

In one case in which utilization was thought to be conservative, Mr. Cary, the author of the article, says that 36 per cent of the material on the tract was utilized, 47 per cent was needlessly wasted, and 17 per cent was left to grow. Measurements taken on the Kennebec River showed that 33⅓ per cent of the trees actually cut was wasted in stumps and tops, and Mr. Cary further states that this is a good average for the region at the time the cutting was done.

Another series of measurements showed that 71 per cent of the merchantable contents of the trees cut was utilized. In this case, however, men were cutting from their own land, and naturally logged more carefully than if the work were being done by contract.

In still another case measurements show that in trees up to 14 inches in diameter, 57 per cent of the merchantable contents of the trees cut was actually utilized, and that in the case of trees over 14 inches, 66 per cent of the merchantable contents of the trees cut was utilized. This cutting was done by a purchaser of stumpage in virgin timber in which the trees were comparatively large and the waste should have been small.

In another series of measurements on still another cutting in which the circumstances and locality were the same as for the data last given, 56.9 per cent of the material cut was saved. For another region the measurements (Blodgett rule) taken show that 84 and 86 per cent of trees cut under and above 14 inches, respectively, were actually utilized. A series of measurements where the cutting was done by owners of land for their own mills shows that with trees up to 14 inches in diameter, approximately 70 per cent of the material was utilized, and with trees over 14 inches 72 per cent was util-

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ized. These data include only the waste in stumps and tops and not the valuable material used in road construction when other timber was available, partly merchantable trees which were not cut at all, and the loss occasioned by disregard of reproduction.

Measurements taken on 32 trees cut on the Fort Wingate Military Reservation showed that 23 per cent of the merchantable contents of the trees cut was wasted in tops and stumps.

In a national forest sale in southern Wyoming in a stand made up of Engelmann spruce and lodgepole pine, chiefly the latter, 58 per cent of the total cut was utilized as hewn railroad ties, 24 per cent as mining props, and 18 per cent as saw timber. In many of the old operations of this region ties were cut and the timber suitable for other materials, such as props and saw timber, was left in the woods. In many other operations materials other than ties and saw timber have not been utilized. It is obvious, therefore, that in such cases about 24 per cent of the merchantable material, on the basis of the sale above mentioned, was left in the woods.

The following extract from Forest Service Bulletin No. 69 gives an idea of the utilization of valuable species, such as the sugar pine. While utilization was close under the existing conditions, it is much more so at the present time because of still higher market prices.

From a financial standpoint there is almost no waste in logging, though often the actual waste of timber is considerable. Stumps are cut 3 feet in height or even less, merchantable logs are seldom left in the woods, and the trees are cut fairly well into the tops. The size at the end of the last log varies a good deal with the character of the individual tree. In general, logs are cut to about 14 inches at the small end, though occasionally they may be cut as small as 10 inches.

From what has been said it may be judged that the lumberman is beginning to realize the necessity of logging as closely as possible. How close he may log must depend on his particular operation and the attending conditions. Since these conditions vary greatly, it is natural that the economy of logging operations should also differ widely. Most of the large concerns are now hauling to their mills sugar-pine logs that have been lying on the ground thirty or forty years. The sapwood of these logs has, of course, rotted away, but the heartwood is usually as sound as on the day the trees were cut. One big lumber company is cutting its tops and limbs into firewood, which it handles at a small profit per cord. This it is enabled to do by the existence of a good market near at hand, with which it is connected by its own railroad.

At least one company has reduced its loss in the fire-scarred butts of sugar pine to a minimum, for it cuts the butt log as though the fire scar did not exist, hauls it to the mill, and as far as possible, cuts it into full-length boards. What is left is then cut into "shorts."

The following extracts from an article in the Dixie Wood Worker of December, 1905, gives a lumberman's estimate of the loss in logging in the southern pine region:

CUT THE STUMPS LOWER.

Most woods foremen allow the stumps to be cut too high. From 2½ to 3 feet is the average in the southern pine region. * * * Nevertheless, the southern pine woods foreman permits a large amount of timber to be ruined by allowing his saw crews to fell timber across stumps, or down timber, and to break off standing trees by the falling of others against them. The appearance of most cut-over pine land in the South shows how very great the damage is from this source. The ground is strewn with broken tree sections which have been butted out, and is dotted here and there with the splintered trunks of promising young trees deprived of their crowns. In heavy stands of southern pine as much as 400 feet per acre on an average is sometimes destroyed by the careless felling of timber. A zealous woods foreman would put an end to a

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large part of this careless waste by insisting that the sawyers use the greatest caution in felling timber. A certain amount of breakage is, of course, unavoidable, but most of it is due to sheer carelessness on the part of shiftless workmen. Such men often waste wantonly several times their wages in timber. Summary discharge of the conspicuously careless would have a good effect on the rest of the men. * * *

A good woods foreman will impress on his saw crew the importance of so arranging their log lengths that a bad defect, such as a punk knot or rot hole, will come at the end of the log rather than in the middle of it. In many cases it would be best to butt out the bad place. If left in the middle of the log, however, it is impossible to trim the defective boards at the mill, and they must grade as No. 2 or No. 3 common.

Another bad arrangement of log lengths is to run the end of an otherwise clear log just beyond a large knot or pitch pocket, making it necessary to trim away the defective end in order that the boards may grade as clear. The defective part might just as well have been put into the next log, which is knotty and will make only the lower grades.

DECIDING ON WHAT LOGS TO CULL.

The skill of the woods foreman is never tried more severely than when he decides what logs are not worth sending to the mill. Crooked, hollow, swell-butted, and doty logs, each is a problem in itself, and at best the judgment of the foreman is only guesswork. Close observation of what defective logs saw out in the mill will, however, enable him to guess more accurately from day to day. Lumber companies waste a great deal of money by sawing timber so small or defective as to be not worth taking; on the other hand, other lumber companies waste money by leaving in the woods timber which really would pay for the taking. I know of an instance where a lumber company operating in southern pine in one of the Gulf States made it a practice to leave in the woods all knotty, top logs below a certain diameter. The cut-over lands of this company are strewn with tops, many of which contained logs 10 to 18 feet long, more or less knotty. The company based its rule on the assumption that such logs would not saw out anything better than No. 2 commons; yet a study of the results from sawing this same class of material in a neighboring sawmill disclosed the fact that they yielded enough of No. 1 commons to afford a nice margin of profit.

The great item of waste in logging in the Northwest is breakage, and a little additional height in the stumps, which may seem unnecessary, really reduces, it is claimed, to a great extent the loss which might otherwise occur from this cause. In the larch operations of northern Montana, Idaho, and eastern Washington, lumbermen consider it necessary to cut off quite a large piece of the butt log of large trees in particular. This, in operations in the national forests where it is necessary to drive the logs which are utilized, amounts to as much as 5 or 10 per cent of the total cut of the species. In private operations, however, the loss from this practice alone is very much greater. The great percentage of loss in redwood operations is too well known to require comment. No accurate data, however, are available.

The utilization of saw timber throughout the hardwood region is, as a rule, very incomplete. In parts of the hardwood district in which coal and gas are available and cheap for fuel, all of the material suitable for cord wood must be left, in addition to the waste in the saw-timber product. In other parts of the hardwood region where coal and gas can not be obtained at low rates, the material which is not utilized for saw timber is disposed of as cord wood. Frequently, however, far too much material which is suitable for saw timber is worked into cord wood. The Doyle scale rule, which is almost universally used in the hardwood district, is perhaps responsible to

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some extent for the waste, on account of the very small value it allows for small logs.

Forest Service Bulletin No. 73 states that by a judicious selection of the proper lengths for cutting logs as much as 25 per cent may be saved in some cases. It is necessary for the woodsman to be able to judge accurately from the outside appearance of the log the kind of lumber which it will cut. The appropriate selection of log lengths throws serious defects into such parts of the log that the amount of waste is reduced to a minimum.

In the report on "Forest conditions in Kentucky," Messrs. Holmes and Bradfield, of the Forest Service, estimated that the waste in floating, weathering, and discoloring in driving logs amounts to at least 10 per cent, and if logs are stranded or in any other way delayed for two or more seasons in reaching the mill this loss amounts to 15 to 20 per cent.

Mr. Patterson, in a report on the cutting of a company in western Kentucky, states that stumps are cut from 22 to 30 inches in height, and that the average loss per tree at the stumpage rates paid in the year 1905 was 15 cents.

SHINGLES.

The great bulk of shingles which are made in the East are manufactured from material which would otherwise go to waste; that is, from slabs, short pieces, etc. In the West, however, particularly in the cedar district of Washington and in Oregon, operations in which cedar is the only product are common. Stumps are necessarily cut very high, since, on account of the grain, a good grade of shingles can not be made below the point at which the butt swell begins. These stumps, however, are not very much higher than stumps in a saw-timber operation. Cedar for shingles can not be utilized so far into the tops as saw-timber material on account of limbs and knots, but this waste is not so great as might at first appear, because of the very rapid taper of the average cedar tree. Operations confined to cedar for shingles alone usually result in considerable damage to the remaining timber which is not removed. Since many of the cedar-shingle operations of the present time include only dead timber, utilization in that respect may be classed as very complete. The fact that cedar is split into bolts before manufacture is responsible for quite a large percentage of waste.

PULP WOOD.

Considerable data have already been given regarding waste in operations in the Adirondacks and New England in pulp-wood operations. The great bulk of pulp wood is obtained from the spruce region of the Adirondacks and the Northeast, and, as a rule, utilization at the present time is wonderfully complete. As previously stated, tops are commonly taken to a diameter of 5, or even 4, inches, and stumps are cut low.

WOOD FOR DISTILLATION.

Utilization in the woods for materials to be used for distillation is probably as complete as for any other operation in the United States to-day.

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HEWED CROSS-TIES.

The following extract from Forest Service Circular No. 118 gives an idea of the waste in tie making in eastern hard woods.

Tables 1 and 2 give a clear idea of the wastefulness of the present methods of tie production. Out of every 100 trees cut for ties over 63 are taken to a top diameter of from 10 to 13 inches instead of 9 or 9½ inches, the smallest diameter from which a 6 by 8 inch tie can be made. Out of 100 trees of 14 inches and over whose butt logs could be split, two-thirds remain entirely unsplit, and of the remainder only a small number are split into the number of ties justified by the size of the logs.

Table 1 brings out strikingly the wastefulness of the present manner of tie cutting. Where ties were being cut, 100 trees, embracing all diameters from 10 to 19 inches, were measured, the actual number of ties yielded by each ascertained, and the total cubic contents of each of the trees, as well as the contents of the portion used for ties, computed.

TABLE I.—*Waste in producing slab cross-ties.*[a]

Diameter of trees breast-high.	Volume of usable length of tree.	Volume of used length of tree.	Ties produced.	Waste of used length of tree.		Waste of usable length of tree.		Wood used for one tie based on used length of tree.	Wood used for one tie based on usable length of tree.
Inches.	*Cu. ft.*	*Cu. ft.*	*Number.*	*Cu. ft.*	*Per ct.*	*Cu. ft.*	*Per ct.*	*Cu. ft.*	*Cu. ft.*
10	14.3	6.1	1.3	2.6	43	10.8	76	4.7	11.0
11	18.5	9.5	1.7	5.0	53	14.0	76	5.6	10.9
12	22.7	12.8	2.1	7.2	56	17.1	75	6.1	10.8
13	27.0	16.2	2.5	9.5	59	20.3	75	6.5	10.8
14	31.8	20.0	2.9	12.3	62	24.1	76	6.9	11.0
15	37.6	24.5	3.3	15.7	64	28.8	77	7.4	11.4
16	45.0	29.6	3.7	19.7	67	35.1	78	8.0	12.2
17	54.5	35.7	4.2	24.5	69	43.3	79	8.5	13.0
18	65.5	43.1	4.7	30.6	71	53.0	81	9.2	13.9
19	76.5	51.3	5.2	37.4	73	62.6	82	9.9	14.7

[a] Assuming each tie to contain 2.67 cubic feet.

Thus from 43 to 73 per cent of the logs used for ties and from 75 to 82 per cent of the whole tree are entirely wasted. This waste is enormous, if we consider how much wood must be consumed to produce the 20,000,000 or more ties which are each year cut in the region. It amounts to about 221,000,000 cubic feet of wood, on the basis of the entire merchantable contents of the tree, or 140,000,000 cubic feet of logs, on the basis of the part actually cut. Of the total amount of timber cut for ties nearly three-fourths is wasted. That this waste can be much reduced is proved by tie cutting in Germany. There also the majority of ties are hewed, while the common tie is larger than our standard tie. It is 8.17 feet (2.5 meters) long, has 10.2 inches (26 cm.) face, is 6.29 inches (16 cm.) thick, and contains 3.5 cubic feet instead of our 2.67 cubic feet. Yet in Germany it takes only from 4.4 to 5 cubic feet of log to produce one tie, while in this country it takes on an average from 7.5 to 8 cubic feet of log to produce a smaller tie. In spite of very strict specifications, the waste of timber in hewing does not there exceed 30 or 40 per cent of the log, while in this country it reaches 73 per cent, to say nothing of the top, which remains entirely unused. The waste in hewing oak ties is greater than in hewing pine ties, since it takes about 11 cubic feet of hardwood timber to produce one tie, and only 9 cubic feet of pine wood. This is due not to any greater waste necessarily involved in hewing hardwood ties, but to the smaller taper and proportionately longer clear length of the pine as compared with oak.

With no inspection of the sizes and characters of the trees cut, the tie makers are guided in their choice of tie timber and the portion of each tree to be used for ties merely by their own convenience and by the ease with which the trees may be hewed into ties. By taking each tree to a top diameter of 9 inches outside the bark, cutting stumps not higher than 2 feet from the ground, and splitting into ties all logs large enough, an increase of from 67 to 185 per cent can be effected in the yield of individual trees above 15 inches in diameter.

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This is shown in Table 2, which compares the average number of black-oak ties obtainable under the present practice and the number possible under more economical methods of tie cutting. The possible yield of ties per tree is based on the taper measurements of black oak.

TABLE II.—*Comparison of the average number of black oak ties per tree obtained under present practice, with the number possible under more economical methods of tie cutting.*

Diameter breast-high.	TIES CUT. Under present practice.	Under more economical methods.	Increase.
Inches.	*Number.*	*Number.*	*Per cent.*
[a] 12	2.7	3.0	11
13	3.0	3.6	20
14	3.3	4.3	30
15	3.6	5.9	64
16	3.9	6.5	67
17	4.2	8.0	90
18	4.5	11.1	147
19	4.9	13.5	176
20	5.4	15.4	185

[a] Trees under 12 inches can not be used economically for ties.

Under more rigid supervision the present yield in ties per acre could in a great many cases be doubled and even trebled, if all trees large enough were made into ties. At present many trees are left uncut, not out of consideration for the future of the forest, but because they are too large, tough, or crooked to be easily hewed into ties, while the straightest and youngest trees are taken because they yield the greatest number of ties with the least effort. Table 3 gives the actual yield of 15 sample acres and an estimate of what could be obtained from them if all the trees of tie size were made into ties under present methods and under more economical methods.

TABLE III.—*Comparative yield of ties per acre under present sytsem and under more economical methods.*

Age of stand (years).	Type.	Actual yield of ties.	Yield by taking all trees of tie size by the present methods.	Possible yield of ties by taking and fully utilizing all trees of tie size.
		Number.	*Number.*	*Number.*
50	Slope	62	106	107
50 to 60	do	38	165	247
48 to 51	Cove	62	209	254
49 to 51	Ridge	100	191	211
60 to 80	Slope	123	140	218
50	do	90	152	154
50	do	48	113	340
53 to 60	do	46	66	94
55 to 65	do	21	52	113
55 to 70	Ridge	23	131	163
56 to 60	do	27	103	121
58 to 60	Slope	46	109	117
60 to 65	do	34	70	102
65 to 70	do	42	105	112
65 to 75	Ridge	54	162	187

By taking all trees that can be made into ties, even as cutting is now practiced, the yield per acre would be increased by from 60 to 125 ties, and with the closest utilization of each tree an increase of 170 ties might be secured from each acre. In this way, to supply the required number of ties, the forest area now annually cut over for ties could be reduced nearly two-thirds and the revenue per acre increased.

The greatest economy would be effected in the utilization of the timber if all trees above 13 or 14 inches in diameter were sawed instead of hewed into

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ties. Where sawed ties are as readily accepted as hewed ones, and where logging is not difficult, sawing will usually prove cheaper and more profitable than hewing.

The following data from Forest Service Bulletin No. 64, published in 1905, give an idea of unnecessary waste in cutting ties in Texas:

WASTE IN HEWED TIES.

Since the tie inspectors do not object to, but even favor ties of greater dimensions than 6 inches by 8 inches, the tie maker never hews a large log to the minimum size. A hewn tie therefore contains as a rule more than the 32 board feet which are contained in a sawed tie of the specified dimensions. This waste of timber, though considerable, is less than that which goes into slabs and chips in hewing.

Table XXV is compiled from records made of the actual yield of 603 trees, and conveys an idea of the sum of these wastes. It shows that from 54 to 71 per cent of the timber cut for pole ties goes into slabs and excessive dimensions. If to this waste is added the timber lost in unreasonably high stumps, and the large tops left entirely unused, the proportion of the tree actually used in the shape of ties is exceedingly small. Thus, only from 26 to 30 per cent of the total volume of the tree is made remunerative, while the rest, 70 to 74 per cent, is either thrown away entirely or practically wasted in making needlessly large ties. These figures of course include some material that could not be used in any case, e. g., the tops above 9 inches. The statement is made in this way solely to show how small a proportion of the forest is utilized and to emphasize the importance of the economies that are recommended farther on.

TABLE XXV.—*Amount of timber wasted by making hewed pole ties.*

Diameter, breast-high.	Total volume of tree.[a]	Volume of round logs in used portion.	Volume of ties cut (6 by 8 inches by 8 feet).	Volume wasted.	
				In portion of tree used for ties.	In the whole tree.[a]
Inches.	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Per cent.*	*Per cent.*
11	24.5	12.9	6.4	50	74
12	31.0	18.0	8.3	54	73
13	36.5	24.2	10.4	57	72
14	42.5	31.6	12.8	60	70
15	48.0	39.3	13.9	65	71
16	55.0	46.8	15.2	68	72
17	62.0	54.3	16.0	71	74

[a] Exclusive of branches.

The figures of the average number of ties actually yielded by trees of different diameters, Table XXIV, do not represent all that could be obtained from the same trees under a more careful and economical system of cutting. Since the tie makers are paid by the tie, their aim is to make as many as possible in the shortest time and in the easiest way. They commonly avoid all crooked and knotty trees, and fell only the tallest and straightest ones, those which will yield the greatest number of ties. Because the butt of the tree is tough and requires most ax work, the stumps are cut as a rule excessively high, seldom less than 2.5 feet in trees of small diameters, and often 3 feet to 4 feet in the larger trees. Many trees, after being felled, are also butted off 3 or 4 feet, because they are too large to be hewed easily. Another means of saving work is to saw the trees through about three-fourths of their thickness, and throw them by means of wedges driven into the kerf. In falling, the tree splits up for a considerable length and leaves a long slab attached to the stump which would otherwise have to be taken off the log by the ax. Old suppressed trees, which after being felled prove hard to hew, are frequently left to rot, or only a small part of what could be made into ties is used. Most of the trees felled for ties could be safely used to a diameter of 9 inches in the top, but the tie cutter, guessing at the size and unwilling to risk making a cull tie (one below

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the specified dimensions), for which he is not paid, remains on the safe side and seldom cuts beyond 10 inches. Often a large part of a tree with a knot or crook, or slightly buried in the sand so that it is difficult to saw into the proper lengths, is left unused.

POSSIBLE SAVINGS IN TIE MAKING.

Many of the wastes that have been just described are easy to reduce or to eliminate entirely. By merely cutting the stumps about 2 feet high or less and utilizing all the tie timber in each tree the average number of ties to the tree could be perceptibly raised.

Table XXVI shows clearly how great a saving may be effected by cutting all stumps at 2 feet above the ground and utilizing the stem to 9 inches in diameter outside the bark at the top. The figures are based upon taper measurements of 603 trees.

TABLE XXVI.—*Average number of hewed ties now obtained from loblolly pine and number that can be cut.*

Diameter breast high.	Number obtained.	Number which can be obtained.	Percentage of increase.
Inches.			
11	2.4	2.5	4
12	3.1	3.5	13
13	3.9	4.5	15
14	4.8	5.5	15
15	5.2	6.0	15
16	5.7	6.5	14
17	6.0	7.0	17

The increased number of ties that it is possible to obtain is somewhat variable, because lengths of 8 feet must always be cut, yet the gain is very real, and amounts to considerable when applied to even 1 acre of forest. Taking the figures of Table I as an example, it requires but a simple calculation to show that the 93 trees between 11 and 17 inches in diameter produced by 1 acre of forest from 35 to 40 years old may yield 45 more ties than they do ordinarily. If this be applied to a piece of land yielding 40,000 ties, the increase will amount to at least 5,000 ties, worth, at the present price of 24 cents a tie, $1,200.

HEWED VERSUS SAWED TIES.

The hewing of ties, however, no matter how complete the utilization of the tree may be, is a most wasteful process, whose extent will be best understood by comparing the volume of average hewed ties with the product of logs of the same dimensions sawed into ties and lumber. By means of a series of diagrams the amount of lumber and ties which can be obtained from logs of various sizes by sawing has been ascertained. A large part of the log, which in hewing is entirely wasted in the form of chips and excessive dimensions, is thus shown to be available for useful material—boards and planks.

It is impracticable to make a direct comparison between the tie and the lumber yield of trees of various sizes, because the hewers might be more saving, and because the lengths obtainable are not always multiples of the tie length, 8 feet, but such a comparison can be made on the basis of logs 16 feet long, which will produce two ties, or lumber of standard length. This is done in Table XXVII, and the possibility of sawing from 23 per cent of the hewed tie volume, in 10-inch logs, to 191 per cent in 15-inch logs is clearly shown. The saving here indicated may rarely be reached in practice, since the logs are not apt to be perfectly cylindrical nor straight, as the diagrams from which the table was made assume them to be, yet after making every reasonable allowance for such irregularities, the waste in hewed ties is striking.

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TABLE XXVII.—*Gain in lumber effected by sawing instead of hewing ties.*

Diameter of log at small end inside bark.	Yield of a 16-foot log—				Percentage of the volume of hewed ties gained by sawing.
	In hewed ties.	In sawed ties and lumber.			
		Ties.	Lumber.	Total.	
Inches.	*Board feet.*	*Board feet.*	*Board feet.*	*Board feet.*	*Per cent.*
10	64	64	14.8	78.8	23
11	64	64	27.0	91.0	42
12	64	64	52.4	116.4	82
13	64	64	70.8	134.8	112
14	64	64	97.2	161.2	152
15	64	128	57.6	185.6	191

TREE SIZES MOST PROFITABLE FOR TIES.

There is a still more important reason why ties should be sawed instead of hewed than the saving of lumber, namely, that the latter method demands those trees which are in their best period of growth. As has been shown, the tie cutters prefer trees 12, 13, 14, and 15 inches in diameter, or between 30 and 50 years of age, when they are still growing rapidly in diameter.

Table XXVIII shows that the rate of diameter increase in trees of the sizes used for hewed ties, though steadily falling, is maintained at more than one-quarter of an inch a year until the age of 50 years is passed.

TABLE XXVIII.—*Increase in diameter of loblolly pine grown in mixture with hard woods on well-drained, fertile soil.*

Age.	Diameter breast high.	Annual increase in diameter.	Age.	Diameter breast high.	Annual increase in diameter.
Years.	*Inches.*	*Inch.*	*Years.*	*Inches.*	*Inch.*
10	2.1	0.40	50	15	0.22
20	6.1	.34	60	17.2	.21
30	9.5	.29	70	19.3	.....
40	12.4	.26			

But the loss that is entailed by cutting immature trees is made much more apparent when the increasing money value of the trees is considered. This is shown in Table XXIX.

TABLE XXIX.—*Rate of increase in stumpage value of loblolly pine trees suitable for ties, grown in mixture with hard woods on well-drained, fertile soil.*

Diameter breast-high.	Value of tree at 3 cents a tie.	Annual rate of increase.	Diameter breast-high.	Value of tree at 3 cents a tie.	Annual rate of increase.
Inches.	*Cents.*	*Per cent.*	*Inches.*	*Cents.*	*Per cent.*
11	7.5	8	15	16.5	2
12	9.9	8	16	18.0	.....
13	12.3	5	17	18.0	.....
14	15.0	3			

These two tables show that the rate of increase in diameter and in value for hewed ties is greater in the smaller trees than in those from 14 to 16 inches in diameter. In other words, the money capital represented by the trees of 11 and 12 inches in diameter increases at a rate equal to an interest of 8 per cent per annum, while the capital represented by trees of from 13 to 16 inches in diameter bears interest at the annual rate of only 2.5 per cent. If the owner of the land were to cut down all the loblolly pine trees between 11 and 13

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inches in diameter and place the money received for them in some safe enterprise, he would scarcely receive such a high rate of interest as he does from the growing trees. If it is necessary that the trees should be cut for hewed pole ties, only those 15, 16, and 17 inches in diameter should be used, as their rate of increase in value is smaller than that of trees 11, 12, and 13 inches in diameter. In this way the capital is allowed to work at a higher rate of interest.

Further, the forest is not threatened with entire destruction. In a forest from which regular and sustained yields are expected, trees of all ages must be present and the young ones must preponderate over the old ones, just as in a self-perpetuating community the number of children must be greater than the number of adults. By cutting out the young trees and leaving the old ones, as is now the common rule, the very existence of the forest is attacked. Since hewing the trees into ties instead of sawing them entails more labor and greater waste, it is clear that to get the greatest income from the forest the practice of hewing must give place to sawing.

There is still another consideration. Trees cut for the mill are usually more fully utilized than those cut for hewed ties. Table XXX, based on actual scaling in the woods of trees cut for hewed poles and of the trees of the same diameter cut for the mill, reveals a greater utilization of the trees in the latter case than in the former one, the increase amounting to from 20 to 45 per cent.

TABLE XXX.—*Comparison of the product of loblolly pine grown in mixture with hard woods on well-drained, fertile soil when hewed into ties and when cut into saw logs.*

Diameter breast-high.	Trees cut for pole ties.		Trees cut for saw logs.		
	Number.	Yield per tree.	Number.	Yield per tree.	Excess in saw logs.
Inches.		*Board feet.*[a]		*Board feet.*[a]	*Per cent.*
11	31	35	9	45	29
12	135	53	32	63	20
13	178	70	50	87	24
14	161	90	64	114	27
15	79	108	78	144	22
16	17	125	79	175	40
17	1	145	79	210	45

[a] Doyle-Scribner log rule.

From the point of view of the forest owner, however, this difference is not apparent. At the present stumpage price for lumber and ties he is willing, in the majority of cases, to have his young loblolly pines cut for ties instead of lumber, because the tie timber brings him a slightly higher price per tree, as can be seen from Table XXXI.

TABLE XXXI.—*Comparative values of loblolly pine from all situations, if sold for pole ties or for lumber.*

Diameter breast-high.	Volume of tree.		Value of tree.		Diameter breast-high.	Volume of tree.		Value of tree.	
	Lumber.	Hewed ties.	At 75 cents per M. board feet.	At 3 cents per tie.		Lumber.[a]	Hewed ties.	At 75 cents per M board feet.	At 3 cents per tie.
Inches.	*Board ft.*	*Number.*	*Cents.*	*Cents.*	*Inches.*	*Board ft.*	*Number.*	*Cents.*	*Cents.*
11	43	2.4	3.2	7.2	15	138	5.2	10.4	15.6
12	64	3.1	4.8	9.3	16	171	5.7	12.8	17.1
13	86	3.9	6.5	11.7	17	207	6.0	15.5	18.0
14	110	4.8	8.3	14.4					

[a] Doyle-Scribner log rule.

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The smaller value of the tree when cut for lumber is due mainly to the log scales now in vogue, which give an exceedingly low scale to small logs as compared with their actual contents. The extent of this difference is shown on Table 32, though the argument for sawing must rest upon other considerations, since it will be hard to alter the established practice in scaling.

TABLE XXXII.—*Comparative log and tie scales of loblolly pine, grown in mixture with hard woods, actually cut for ties.*

Diameter breast-high.	Scale of the unhewed logs.	Ties cut from tree.	Scale of the hewed ties at 32 feet each.	Excess of tie over log scale.	Diameter, breast-high.	Scale of the unhewed logs.	Ties cut from tree.	Scale of the hewed ties at 32 feet each.	Excess of tie over log scale.
Inches.	*Board ft.*[a]	*Number.*	*Board ft.*	*Per cent.*	*Inches.*	*Board ft.*	*Number.*	*Board ft.*	*Per cent.*
11	35	2.5	80.0	129	15	108	5.5	176.0	63
12	53	3.3	105.6	99	16	125	6.0	192.0	54
13	70	4.1	131.2	87	17	145	6.0	192.0	32
14	90	5.0	160.0	77					

[a] Doyle-Scribner log rule.

In this connection it is proper to consider why trees are hewn at all. One would naturally expect that the persistent demand for hewed pole ties, the production of which is coupled with such a waste of timber and the most extravagant use of the forest, must be based on very good reasons, and that the railroads are paying a higher price than for sawed ties, as is the case with those made of longleaf pine and other woods. As a matter of fact, however, hewed and sawed ties of loblolly pine command exactly the same price in eastern Texas. The apparent reason for the preference is that hewed ties are thought to last longer than sawed ones, because the smooth surface made by the ax is less retentive of the water that promotes decay than is the sawed wood. There may be some truth in this when untreated ties are considered, but since all the loblolly-pine ties now used are treated before they are laid in the track the objection does not hold. According to Doctor von Schrenk,[a] sawed ties when properly treated, last as long as hewed ones, and there is no good reason why they should not be used. The farmers of Texas probably will continue to furnish hewed ties so long as they are demanded, in spite of the drain on their forests, but the railroads can easily curtail the waste by encouraging the production of sawed ties. The railroads are heavy consumers of timber in many forms. Besides ties, they require every year enormous quantities of bridge timber, telegraph poles, and lumber for cars and houses. The present wasteful use of young timber for ties, which could readily be avoided, will lead to a rapid exhaustion of the timber supply in general, which can not remain without influence upon the lumber market.

In some instances the cutting of young timber for hewed ties may be justified. Where the stand is very dense the removal of the trees which lagged behind in the competition for light and room would prove beneficial to the growth of those remaining. Since from the several thousand young seedlings which usually start on an acre only from 140 to 160 trees reach maturity, timely thinning would perceptibly increase the yield per acre by furnishing useful material which would otherwise decay in the woods and add to the danger from insects and fires. If, however, the cutting of pole ties were limited to trees removed in thinnings, a qualified person would be required to mark every tree which should be cut, and that could be profitably done only by owners of large forest tracts.

[a] "The Decay of Timber and Methods of Preventing it," by Herman von Schrenk, Bulletin No. 14, Bureau of Plant Industry, U. S. Department of Agriculture, p. 22.

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The following table, taken from Bureau of Forestry Bulletin No. 53, Chestnut in Southern Maryland, shows the total length of material wasted in tops of trees cut for hewn ties.

Diameter breast-high.	Volume.	Length wasted.	Diameter breast-high.	Volume.	Length wasted.
Inches.	*Ties.*	*Feet.*	*Inches.*	*Ties.*	*Feet.*
10	1	51	16	5	41
11	2	48	17	5	43
12	3	44	18	5	45
13	3	49	19	5	47
14	4	43	20	5	49
15	4	46			

The waste of timber which attends the cutting, as shown in the table, is very great, but the demand for chestnut tops for other purposes is comparatively small.

STAVES.

In a report on the tight-cooperage industry Mr. H. M. Hale, of the Forest Service, states that the greatest waste in tight cooperage occurs in the manufacture of split staves. He further states that by far the greater number of export staves at the present time are split. In 1897, 51,120,171 staves were exported. The manufacture of staves by splitting is particularly wasteful, since only butt logs and particularly straight-grained sticks—or, in other words, the highest class of timber—can be used.

The following table of measurements taken in Kentucky shows the diameter breast-high and the top diameter to which white-oak trees were used for split staves:

Diameter breast-high.	Top diameter.	Diameter breast-high.	Top diameter.
Inches.	*Inches.*	*Inches.*	*Inches.*
16	15.1	27	20.7
17	15.5	28	21.4
18	15.9	29	22.0
19	16.3	30	22.7
20	16.7	31	23.3
21	17.2	32	24.0
22	17.7	33	24.7
23	18.3	34	25.3
24	18.9	35	26.0
25	19.5	36	26.7
26	20.1		

It will be seen from this table that the top diameter varies from 15.1 inches in a 16-inch tree to 26.7 inches in a 36-inch tree. It is obvious that the amount of waste, especially in large trees, is very great.

The following facts are taken from a report on Woods for Slack Cooperage and Their Economic Utilization, by J. J. Levison, of the Forest Service. In the manufacture of slack cooperage under present methods it is absolutely necessary to use green timber. Even after green timber is cut it is frequently allowed to lie in the woods

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so long that it becomes too dry or too checked for cooperage purposes. As in the case of saw logs, heading blocks are frequently cut too long. Mr. Levison states that blocks are frequently cut to the length of 21 inches, when only 17⅛ or 15-inch heading will be cut from them. Logs intended for staves are cut in the woods to lengths which are multiples of 32 inches, because of poor judgment in the workman or wood superintendent, and it is often found necessary to utilize at the mill for heading, material which was cut in the woods for staves. In logs which were cut for 6-stave lengths the waste, if it is found necessary to utilize the log for heading, is 3 inches to the log. If, on the other hand, the log was cut for 5-stave lengths, the waste, if it is necessary to utilize this for heading, is 13 inches. Not infrequently, through carelessness of workmen, logs are cut too short in the woods and the last block must be thrown out at the mill. As in other industries, it is necessary to combine several industries in order to secure complete utilization. For instance, in the manufacture of slack cooperage materials (heading, stave, and hoop mills) logs that will not make good hoops will freguently make good staves, and logs which are not suitable for staves will often make very good heading.

The following is an extract from The National Cooper Journal, of November, 1905, on the question of waste in the cooperage industry:

> Here in the veneer mill the man at the drag saw must cut his blocks longer than the veneer to be made from them, so that there may be plenty of room to use score knives and true up the end. Sometimes we work this very closely, and get it down to 2 or 3 inches, and then again there are times when there are from 2 to 4 inches on each end, making a total waste of 6 inches. After marking off the log, then there is a chance that the drag sawyer may have to cut off one end anywhere from 3 inches to a foot of log, and that goes into the waste pile.

POLES.

Operations which have in view only the exploitation of poles, as previously indicated, result in considerable damage to the remaining timber in the stand. In the West and Northwest very frequently it is thought to be necessary to cut very high stumps in order to remove large butts which would make the pole difficult to handle. The actual waste from the practice of long butting alone probably amounts to an average of 5 per cent or more of the material actually obtained. Another cause of waste is the necessity in many cases for cutting to specification.

VENEER STOCK.

The waste in cutting material for veneer stock is very similar to that in hard-wood saw-timber operations in the East. Obviously, however, only clear material can be used to good advantage, and specifications usually provide for diameters larger than 16 inches. Unless knotty logs and those smaller than 16 inches can be used for saw timber and other purposes, and very frequently this is not the case, such material is a total waste.

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MINE TIMBERS.

The following extract from Circular No. 118 contains an estimate of the amount of waste in cutting mine timber in the southern Appalachians:

In logging for mining timbers under present methods fully 40 per cent of the timber handled is wasted. The chief items of waste are high stumps, tops, partially used bolts, and even whole trees, which are felled and rejected because slightly twisted in grain. Of the different timbers used by the mines, the greatest demand upon the forest is for props, which are 3 or 4 inches square by from 4 to 9 feet in length, and for tram ties. Under such conditions clean logging and fullest utilization of the tops to a diameter of 4 inches should present no difficulty, if proper supervision is given to logging operations. To secure close utilization of timber it would be best to saw into the required sizes the rougher material from the tops, as well as the entire stems of those species which are difficult to split, instead of following the present practice of splitting the timber into props and rejecting all logs that will not split readily. If mining timber is cut into bolts of the required lengths in the woods, it can be sawed at the mines to the required sizes at a great saving over the present wasteful methods of manufacture by splitting.

CORD WOOD.

The great bulk of cord wood which is cut in the East at the present time is used for fuel, and a very large percentage of the total amount cut is taken from farmers' wood lots. It is almost the universal practice to cut the best trees for this purpose, since they can be cut and split much more easily than the poorer trees and the poorer species. When it is considered that saw timber is now selling for $5 or more per thousand feet b. m., and soft coal can be produced for from $3 to $5 a ton, the economic loss through the utilization of hard-wood material for cord wood, when it is suitable for saw timber, is very apparent.

A great amount of cord wood is wasted each year by failure on the part of lumber companies to work up cord wood even when there are good markets.

LUMBERMEN'S ESTIMATES OF WASTE.

While few lumbermen have made an effort to obtain exact data on unnecessary loss in logging operations, estimates by lumbermen and by secretaries of lumber associations are of decided interest. In order to obtain such estimates the following questions were sent to the secretaries of representative logging associations throughout the United States:

1. What is the percentage of loss in the average logging operation, or, if possible, in specific cases, through bad management, not considering the specific kinds of loss referred to in the following questions?
2. What is the percentage of loss through leaving inferior species in the woods, failure to cut trees which are partly merchantable, and leaving comparatively inaccessible bodies of timber?
3. What is the percentage of loss by leaving logs in the woods, lodged trees, the use of valuable material for roads or other construction purposes, unnecessarily high stumps, merchantable material left in tops, unnecessary lengths left for trimming, nonutilization of short-log lengths, and breakage in falling?
4. What is the indirect loss through fire and windfall which follows logging operations?

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The following tabulation shows estimates submitted:

	Question—				
	1.	2.	3.	4.	
				Fire.	Windfall.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
North Carolina Pine Association	30	25	20	10	None.
Montana Larch and Pine	.....	3	5	10	None.
National Slack Cooperage Association	.....	[a] 5–25	[a] 2–5	[b] 5–10	None.
	.....	[c] 12½	[c] 5–10	[d] 10–20	None.
	.....	.....	.....	.....	[b] 3–4
	.....	.....	.....	.....	[d] 2–3
Southwest Washington Lumber Manufacturers' Association.	2	25	.....	[e]	None.
Southern Cypress Manufacturers' Association	.....	.....	[f]	.....	.....

[a] Cooperage. [b] Hard woods. [c] Lumber. [d] Soft woods. [e] Very little. [f] Very complete utilization.

LOSS FOR THE UNITED STATES IN 1907.

The following table attempts an application of the data on waste for various classes of material to the cut for the year ending June 30, 1907. It must be borne in mind that the percentage used can not be exact, and accordingly has been placed extremely low in order to be conservative. Logging methods, since much of the data here given were collected, have become much less wasteful, and the percentages given in the data have accordingly been considerably reduced:

Material.	Cut in year ending December 31, 1907.	Equivalent quantity.	Percentage of product unnecessarily wasted.	Waste.
Timber:		*Cubic ft.*		*Cubic ft.*
Soft woods.....feet..	31,001,225,000	2,584,000,000	12½	323,000,000
Hard woods.....do....	9,254,929,000	771,000,000	15	116,000,000
Shingles.....number..	11,824,475,000	106,000,000	5	5,000,000
Pulp wood.....cords..	3,000,000	270,000,000	7½	20,000,000
Wood distillation.....do....	1,280,000	115,000,000	5	6,000,000
Hewed cross-ties.....number..	118,383,000	414,000,000	25	103,000,000
Heading:				
Tight.....sets..	27,693,000	9,000,000	15	1,000,000
Slack.....do....	106,074,000	18,000,000	15	3,000,000
Staves:				
Tight.....number..	385,232,000	32,000,000	15	5,000,000
Slack.....do....	1,175,977,000	29,000,000	10	3,000,000
Poles.....do....	3,500,000	35,000,000	12½	4,000,000
Veneer.....feet..	348,000,000	29,000,000	25	7,000,000
Mine timber.....cubic feet..	165,000,000	165,000,000	12½	21,000,000
Cord wood.....cords..	100,000,000	9,000,000,000	10	900,000,000
Total.....	.....	13,577,000,000	.....	1,517,000,000

HOW FAR CAN THESE FORMS OF WASTE BE REDUCED THROUGH CONSERVATIVE LOGGING?

UTILIZATION ON NATIONAL FORESTS.

The methods followed in handling the sale and cutting of timber upon the national forests, in so far as they concern utilization and the protection of young trees and reproduction, are of decided interest,

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and result in most cases in a reduction to a minimum amount of the unnecessary waste.

The boundaries of sales exceeding $100 in amount in nearly all cases follow natural features, such as streams and ridges, rather than the lines of legal subdivisions. All sale areas are, therefore, natural logging units, and this cheapens exploitation, and provides for the cutting of the comparatively inaccessible as well as of the accessible timber.

All sales include the dead timber upon a tract as well as the living. All species, even though comparatively inferior and difficult to market, are included in the sale.

The clauses of a national forest timber-sale contract which relate to utilization and the protection of the valuable species are taken up in detail.

Clauses provide for the marking by forest officers of all live timber that will be cut, and for a penalty of double stumpage rates for all unmarked living trees which are cut and all marked trees which are left. This enables forest officers to control absolutely the cutting of trees which, for the good of the forest, it is desired to remove, and retain those which, for the protection of the forest and the provision for a second cut, it is desirable to retain.

A clause names approximate minimum diameter limits to which trees will be marked, and makes provision for the variations of these limits for the good of the forest. In order that purchasers may know the plan to be followed, sample areas are marked upon application in advance of sale. The minimum approximate limits are varied with the species to leave more and larger trees of the desirable species, in order to perpetuate them against those trees whose proportions in the stand should gradually be reduced.

Other clauses provide for payment for merchantable timber used in construction work, in order to encourage the use of inferior trees and of unmerchantable dead timber wherever feasible; for the use of saws rather than axes in order to reduce the percentage of unnecessary waste; and for the closest possible utilization in the stumps and tops. These clauses are still further strengthened by a provision for a double stumpage charge for material wasted.

Another clause binds purchasers to the protection of young trees and those which are to be left, and provides penalties for careless work.

Provision is also made for brush disposal in such a manner as to reduce the fire menace to a minimum, or make the best provision for reproduction; and for a fire-fighting force to be at the call of the local officers of the Service.

Still other clauses provide for an overrun in logs, and a penalty charge if the overrun is exceeded; and require the purchaser to pay for material suitable for saw timber at saw-timber rates, thus guarding against the use of saw-timber material for cordwood.

All national forest timber-sale contracts require the utilization of all possible material under existing conditions.

One sale in western Montana includes saw timber, mining stulls, converter poles, lagging poles, and cord wood, and utilizes all merchantable material which the purchaser is allowed to remove, to a diameter of 3 inches.

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That lumbermen are purchasing timber under these restrictions and are making a profit from their operations is conclusive proof that much of the waste in the ordinary cutting is absolutely unnecessary.

ILLUSTRATIONS FROM PRIVATE OPERATIONS.

The following extract from Forest Service Circular 131, by Mr. Austin Cary, shows what may be done by complete inspection to reduce the unnecessary waste in logging. The plan would apply equally to practically all kinds of logging operations on private lands:

Windfalls and dead standing timber are common in the virgin spruce woods of New England, and come under this head (cases in which the required utilization can not be definitely defined). The trees are often defective, and are more expensive to haul than live timber, but with present lumber prices it means a distinct loss to the owner if such material is left on the ground. At the expense of a good deal of labor thrown away in testing, this class of timber was carefully picked up. In just such a case as this, where expense has constantly to be balanced with availability at the mill, was shown the utility of inspection. A thoroughly posted man was on the ground every two or three weeks during the logging season to explain requirements, settle doubtful points, and keep things up to tone. That this paid for itself was perfectly evident. If ordinary logging was costing $4 per thousand, it might cost half as much more to pick up the windfalls and dry timber, a fact which told in the average cost of the whole cut. And yet at that figure there was a margin on even low-grade lumber, while much of the material gained was as good as the best. As a matter of fact, the rate of profit on all this class of stuff was larger than that on the main ouput of many other industries, while the amount saved the company would have made a handsome business for many lumbermen.

Below is a copy of the inspector's report as used by the Berlin Mills Company from Forest Conditions in Maine in 1902:

Camp of_____, township_____
Date _____
Date of last inspection_____
Force _____
How employed _____
Ranked or yarded to date_____
Number of crews cutting_____
Stumps (if unsatisfactory specify number and crew)_____
Tops (if unsatisfactory specify number and crews)_____
Length of logs_____
Are they carefully butted and trimmed?_____
Dead and down timber_____
Fir_____
Are any logs, poles, or lodges left?_____
Remarks _____
Plan of cutting (marking, size limit, clean cutting, etc.)_____
How adhered to?_____
By whom are roads located?_____
Is soft wood cut for skids and bedding?_____
Is care exercised to protect small growth?_____
Remarks _____
Are all logs marked and stamped?_____
Two sledding _____
Landings _____

(Signed) ——— ———.

This inspection report represents the most effective control which we have been able to exert on our logging bosses and contractors. The work of each camp is inspected once every three weeks, and the past winter all the roads cut by the crew in the interval were gone over by the inspector, looking carefully after each item of waste. By this means foremen have been stimulated to look more carefully after this work than ever before, and in respect to

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economy at least, loss of stuff left in the woods, greatly improved results have been obtained.

* * * * * * *

Below is a summary of the waste discovered in the work of six camps which were under the inspection of the writer during the winter of 1901–2. In explanation it will be necessary to append the following: By poles are meant small sticks scaling 20 feet or less, b. m., and down to about 7 inches on the stump. Under down and uprooting trees is put everything of that description seen on the ground cut over. In some cases these trees lay so hard no man would go after them; in others they may have been easy to get. The two classes can not be distinguished here. The waste in stumps and tops is a matter of judgment in which the inspector might be a good deal off, as no very extended studies or computations were made in the matter. Where a man kept his work as close to orders as could with reason be expected, no charge was made against him. Stumps were to be cut down to the swell of the roots and shoveled out if the snow was deep enough to require it. It was meant that no tops should be cut larger than 6 inches, and by far the most were much less.

This table shows the merchantable timber left to waste by six Berlin Mills Company's camps under close inspection:

Camp.	Total lumber cut.	Waste in stumps and tops.	Logs and trees cut and left.	Poles.	Lodged trees.	Standing dry timber.	Down and uprooting trees.	Sure to blow down.	Total.	Percentage of cut.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
No. 1	2,000,000	.....	1,000	100	.....	500	6,300	4,200	12,100	0.6 of 1
No. 2	2,400,000	11,600	2,300	1,400	200	6,500	10,500	7,500	40,000	1.7
No. 3	3,400,000	35,000	5,400	6,000	6,000	3,500	27,000	17,100	100,000	3
No. 4	3,400,000	1,400	1,900	2,000	1,100	1,000	10,600	4,000	22,000	0.65 of 1
No. 5	2,500,000	30,500	2,200	5,500	2,000	4,200	10,300	6,000	61,000	2.3
No. 6	1,900,000	3,000	100	300	1,200	3,000	4,600	2,800	15,000	0.8 of 1

Total waste in 15,600,000 feet cut, 250,000, or 1.47 per cent. That can and will be improved upon, but still there are logging concerns in the State which waste twenty times as much in proportion.

The term "sure to blow down," as applied to stuff left by the loggers, explains itself. In most of the operations it was not meant to strip the land, but to leave the smaller timber to grow, where it could be safely done. Whether it will be safe is, of course, a matter of judgment. In inspecting I meant to be conservative, noting only what any experienced man, if he gave his mind to it, would feel sure was doomed to fall. I expect there will be more loss by wind in the future than is here included. Of course, it is understood that I do not claim to have seen all the waste that occurred. Some of it was covered up by brush and tops so that no man could get it all.

The following data show the comparative amount of waste in cutting stumps in two logging operations in the Adirondacks in which conditions were very nearly the same, and show very conclusively that under a system of inspection the waste in logging can be reduced. The data are taken from the preliminary working plan for Adirondacks lands belonging to the Hon. William C. Whitney, by H. S. Graves, 1899:

Average height of stumps cut at Santa Clara in 1898, and at Nehasane, N. Y., in 1897.

Diameter of trees.	Average height of stumps.	
	Santa Clara.	Nehasane.
Inches.	*Inches.*	*Inches.*
9	17	26
10	18	25
11	19	26
12	20	29

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COMBINATIONS OF WOOD-USING PLANTS.

One of the most promising methods of securing complete utilization is through a proper combination of different kinds of wood-using plants. The national forest sale previously mentioned serves as an excellent illustration of such a combination. Sticks not less than 6 inches in diameter at the small end and not less than 12 feet in length, which are sound enough for mining timber or lumber, are cut into mining stulls or are used for saw timber. Converter poles are from 3 to 5 inches in diameter, and at least 20 feet long; logging poles are from 2 to 4 inches in diameter, and 12 or 16 feet long. All material, dead and living, to 3 inches in diameter, not suitable for the purposes mentioned, is utilized for cord wood.

A combination of sawmill and box factory provides for a most complete utilization, since top logs to a small diameter and exceedingly short logs, if transportation facilities are such that they can be brought to the mill, can be used profitably, and grades unsuitable for lumber make excellent box boards.

Sawmills and pulp mills are frequently combined to good advantage in the North and Northeast. The sawmill uses the large logs and the pulp mill the small logs and the slabs from the sawmill. Very frequently, where market conditions and transportation facilities warrant, it is possible to utilize material which is not suitable for saw timber, mining timber, etc., for cord wood.

The mixed hardwood forests of the East are composed of so many species especially adapted to different uses that complete utilization may be secured best by the operation of several plants. If combinations could be made of sawmill, cooperage, box, veneering, and turning plants, and waste of various forms could be used as cord wood, unnecessary waste in the hardwood region could largely be disposed of. Obviously, complete combinations of this kind are not everywhere feasible, but partial combinations would greatly improve present conditions.

The most powerful factor in securing complete utilization will be higher prices for the manufactured product. While the value and importance of various economies will be recognized by lumbermen, not until the scarcity of timber reflected in high prices makes it absolutely necessary for every concern which operates to utilize completely all merchantable material, will lumbermen practice strict economy of the forest resources on their timber lands. The statement is proved by conditions in European countries to-day. Utilization is complete in those countries where prices are high. Where prices are low, for instance in northern Norway, utilization is not more complete than in the United States.

The quotation from Forest Service Circular No. 131, shows the profit in one case from the utilization of inferior materials and close cutting in tops and stumps; and in other cases where only utilization and not the perpetuation of the forest is being considered there is no excuse, when the visible supply and demand in the United States is considered, for failure on the part of an operator to remove all material which can be disposed of at a profit.

In an article in the American Lumberman on "Waste and economy in handling North Carolina pine," Mr. George W. Roper states that factories are not allowed to ship as merchantable lumber in the rough

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any pieces shorter than 10 feet, and further states that the pieces of this length are limited to a certain percentage. Mr. Roper states that mills should sell No. 1 and No. 2 strips to a minimum length of 4 feet, and that pieces of both even and odd lengths, that is, 4, 5, 6, 7, and 8 feet, etc., should be placed on the market.

When the markets become such that short and odd lengths are salable and sawmill machinery is so adjusted as to allow the sawing of short logs, it is bound to result in much less waste in the woods.

Though apparently insignificant, the scale rule is responsible for much waste. In some cases a short log with a large diameter actually scales more than if the same log had been cut longer, but with a smaller top diameter, although the latter actually contains more lumber. So long as this condition lasts, it will be exceedingly difficult to require contract loggers, for instance, to log without waste.

PROTECTION OF REPRODUCTION.

Not until lumbermen believe that provision should be made for a second cut, and that forestry can be practiced on private lands at a profit, will the protection of reproduction in the logging operation itself and through the proper disposal of slash be seriously considered. The most reliable estimate which it is possible to obtain at the present time shows that the available supply of timber at the present rate of cutting will be practically exhausted in from twenty to thirty years. If lumbermen can be shown that by modifying present methods of cutting it is possible to provide for a second and clean cut within some such reasonable time as thirty years, not only will the economic gain to the country be incalculable, but what concerns the lumberman more, the vital and financial returns from the first cutting will not be greatly lessened because of more complete utilization, and at the same time provision will be made for large future returns. The cost of such management will be the possible initial increased cost of logging, and possibly reduction in present returns, the cost of technical management, and finally the cost of patrol and taxes. Taxes on cut-over lands, while probably excessive in most States at present, will without doubt be reduced to a just basis when the States fully understand the necessity of providing by judicious taxation for a future timber supply.

SUMMARY.

Data collected by men who are thoroughly familiar with market conditions and the possibilities in the utilization of timber show that at the present time in the United States there is much unnecessary waste in logging. This fact is also acknowledged by lumbermen. This unnecessary waste occurs because of conditions, or prejudice, or various kinds of bad management resulting in—

Poorly conceived and poorly executed logging plans.

Failure to remove from the woods merchantable material which is actually cut.

Failure to cut and remove inferior trees, partly defective trees, and inferior species which are merchantable.

Failure to remove small bodies of timber in comparatively inaccessible places on which the profit is low.

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The removal of only one class of material from the forest when others are present and merchantable.

Failure to utilize merchantable dead timber.

When inferior trees and inferior species are available, the use for construction work of valuable species and valuable trees which can not be otherwise utilized at a later time.

Failure to use materials for the purposes to which they are best suited.

The cutting of trees for tan bark only, and waste of the logs.

The cutting of unnecessarily high stumps.

Failure to utilize all of the merchantable material in tops suitable for saw timber or cord wood or other use.

Failure in requiring the proper variation in log lengths.

The nonuse of odd and short log lengths.

Unnecessarily long trimming lengths.

Unnecessary breakage in felling and transportation.

Too great loss in driving; and

Careless use of logging machinery such as donkey engines.

In addition, through economic conditions such as taxes, low prices for manufactured products, ignorance and disregard of the value of young trees and reproduction, and the necessity of providing for future crops, the possibilities of future timber supplies have been greatly reduced, and the time for producing such supplies greatly extended through unnecessary damage to reproduction and young trees in logging operations, and the fires which follow logging operations in many cases because of failure to dispose properly of the slash resulting from the cutting.

Experience has shown that unnecessary logging waste on private lands may be reduced to less than 1.5 per cent by a proper form of inspection which, in modified forms, is fully applicable to all cutting on private lands.

Unnecessary waste in national forest cuttings through carefully prepared contracts and frequent inspection is not greater than 1.5 per cent on the average and in many sales the amount is negligible.

Suitable combinations of different kinds of wood-using plants can bring about a great reduction in unnecessary logging waste.

Increasing market prices without other influence will gradually bring about complete financial utilization, since lumbermen who log carelessly will not in the long run be able to compete successfully with lumbermen who utilize as fully as conditions will allow the products of the forest. This condition may, however, be greatly hastened by the means suggested.

The proper protection of the reproduction and of young trees in logging operations and the disposal of slash in such a manner as to reduce the fire menace in cut-over areas to a minimum will not be considered by lumbermen until the feasibility of conservative forest management has been demonstrated to them.

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WASTE IN MILLING.

By LOUIS MARGOLIN,
United States Forest Service.

SUMMARY.

WASTE IN MILLING.

In converting logs to lumber there is entailed a heavy waste. This waste may be necessary or unnecessary, and it may entail a total loss or only a relative loss.

Under present methods of manufacture the principal sources of waste are as follows:

1. Loss of bark; 10 to 20 per cent of the total volume of the log, with an approximate average loss of over 13 per cent. (See Table 3.)
2. Loss due to kerf; 15.5 per cent of the volume of the peeled log, or 13.5 per cent of the total volume of the log.
3. Loss due to edging and trimming; 10 per cent of the volume of the peeled log, or 8.7 per cent of the total volume. (See Table 2.)
4. Loss due to slabs; 10 per cent of the peeled volume, or 8.7 per cent of the total volume of the log. (See Table 2.)
5. Loss due to careless manufacture and accidents (not included in the above); 4 per cent of the peeled volume, or 3.5 per cent of the total volume of the log.
6. Loss due to standardizing lengths and widths of boards; 2 per cent of peeled volume, or 1.7 per cent of total volume.

The total loss from all sources is 49.1 per cent of the total volume of the log, and each cubic foot of log with bark yields, therefore, on an average 6.1 board feet of lumber.[a]

To manufacture the 40,250,000,000 feet of lumber produced in 1907 required 6,600,000,000 cubic feet of wood.

A portion of the waste is necessary and can not be avoided, but a large percentage can be saved in the following ways:

1. By the general adoption of thin saws—band saws and resaws.

[a] It may be of interest to compare this figure with the two standard log rules—the Doyle and the Scribner.

The average size of log cut in the United States is probably about 18 inches in diameter at the small end. Allowing a taper of 1 inch to 8 feet, the total volume of a log 16 feet long and 18 inches in diameter, peeled, is 31.5 cubic feet. The total volume of such a log, including the bark, is 36.21 cubic feet.

A log 16 feet long and 18 inches in diameter scales, according to the Doyle rule, 196 board feet, or 5.4 board feet per cubic foot of unpeeled log. The same log, by the Scribner rule, scales 213 feet, or 5.9 board feet per cubic foot of unpeeled log.

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2. By the elimination of gang saws.
3. By manufacturing in round-edged or "wany" form a large part of the lumber which is to be worked over.
4. By modifying market requirements and usage so as to allow boards of random widths and odd lengths.
5. By admitting short and narrow boards.
6. By modifying standard grading rules to allow defects on ends and edges without seriously reducing the grade of a board.
7. By more careful manufacture and more perfect machinery.
8. By utilizing short boards, slabs, and waste for such articles as matches, toothpicks, excelsior, novelties, and other purposes for which large boards and planks are now used.

Under present economic conditions and until more perfect machinery is devised the following wastes are considered unavoidable:

1. Practically the entire bark (except what may be used in tannin)—13 per cent of the total volume of the log.
2. Kerf—10 per cent of the total volume.
3. Loss from edging and trimming—5 per cent of total volume.
4. Loss from slabs—5 per cent of total volume.
5. An additional 1 per cent for unavoidable accidents.

Total necessary waste, 34 per cent of total volume of log, which leaves an unnecessary waste incurred under present methods of over 15 per cent of the total volume. In other words, over 30 per cent of the present waste is unnecessary and can be avoided.

Part of the waste is relative, but it is roughly estimated that the part utilized represents only 8 to 9 per cent of the value of the lumber which the waste represents.

WASTE IN MANUFACTURE OF VENEER.

The main sources of waste in the manufacture of veneer are as follows:

1. Trimming defective ends—3.5 per cent.
2. Loss through checks and cracks—6 per cent.
3. Loss through damaged sap—3.2 per cent.
4. Loss of cores—3.1 per cent.
5. Loss through breakage—5 per cent.
6. Loss through imperfect drying—4 per cent.

The total from sources mentioned is 24.8 per cent of the lumber manufactured.

In addition there is a loss of at least 5.2 per cent from miscellaneous sources, such as kerf in sawed veneer, carelessness, miscut veneer, etc., bringing the total loss up to about 30 per cent. This is equivalent to a loss of over 100,000,000 feet of the 348,000,000 feet manufactured into veneer in 1907.

WASTE IN MANUFACTURE OF COOPERAGE.

The main sources of loss in the manufacture of cooperage are:

1. Allowing logs to dry and check in the woods.
2. Cutting logs into bolts and allowing an overrun of one or more inches in the length of each bolt—7.7 per cent.
3. Improper bolting and the conversion of bolts into staves.
4. Carelessness in stave jointing.

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5. Seasoning the finished product—about 4 per cent.

Although no detailed figures for the loss incurred through each of the above sources are available, yet it is estimated to be 40 to 50 per cent of the sound lumber, or, assuming an average of 45 per cent, 56,250,000 board feet on the 1,250,000,000 board feet used for cooperage stock in 1907.

The method of reducing the loss is through greater care in the various processes of manufacture, better and more highly specialized machinery, and a more thorough utilization of the waste.

An attempt has been made in this paper to point out the usual source of waste in converting logs into lumber. At least a part of this waste is shown to be unnecessary. Most of the waste is due to the low value of lumber when compared with other factors of production, such as cost of labor, freight rates, etc. With the growing scarcity of wood and its consequent rise in value ways will be devised for reducing the waste. As long as it is not possible for the Government to exercise a control over the use and misuse of the natural resources, an unnecessarily heavy waste may be expected all along the line.

WASTES AND LOSSES IN MILLING.

INTRODUCTION.

In converting trees to usable shape and form, whether the form be firewood, boards and plank, dowels, or veneer, there is entailed a certain amount of waste, which varies mainly with the form of the product and the value of the wood.

Loss and waste should be distinguished. Loss occurs when material is sacrificed because it can not be used with profit. Waste occurs when only a part of the possible marketable product is extracted; it may be due either to carelessness or ignorance.

This paper will consider the wastes and losses involved in milling. It will consider the log from the beginning, carry it through the various processes in the mill, and show the waste at each operation. In addition, a brief description will be given of the waste connected with the converting of logs into cooperage and veneer stock.

The figures used are taken mainly from two sources. The first of these are mill tallies made by the Forest Service in various regions for the purpose of determining the amount and grades of lumber cut from different sized trees; in connection with this work some 40,000 logs of a dozen different species were measured in the woods and followed through the mill. As to the second source, circular letters were sent to 2,000 of the leading mill men in the country; replies were received from 540 manufacturers whose operations represent an annual cut of 7,121,000,000 board feet. In addition, a circular letter was also sent to 800 cooperage and 250 veneer makers.

Very often wastes can not be expressed in exact figures. The waste due to careless handling of the "nigger" or to the reduction of the grade of lumber caused by careless sawing is of this kind. In such cases care was taken to estimate the waste as accurately and conservatively as possible.

VARIOUS PROCESSES IN A TYPICAL MILL.

It may not be out of place here to give a brief description of the various processes through which a log passes in a typical mill. On

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reaching the log deck the log is put on the carriage by means of "kickers" and "loaders." It is turned on the carriage by means of a long iron pole fitted with sharp hooks known as the "nigger." As each slab is sawed off the log is pushed forward toward the saw by means of a "setter." The slab is separated from the log by the "off-bearer" and is sent on to the "edger" where the waney edges are sawed off and the edged board goes on to the "trimmer," which cuts or trims off the ends and reduces the boards to a standard length. The boards are then "inspected" or graded and sent to the lumber yard where they are stacked and seasoned, either in the open air or in a dry kiln. Almost every one of these steps involves some waste.

WASTE IN SAW KERF.

One of the chief wastes in converting logs into lumber is saw kerf. This waste varies with the thickness and gage of the saw and the care with which the sawteeth are swaged. It varies also with the thickness of the lumber—the thicker the lumber the less being the amount of kerf in proportion to the size of the log.

The two most common forms of saws used in the United States are the circular saw of 8-gage thickness, swaged to cut about one-fourth inch kerf, and the band saw of 14 to 16 gage thickness, swaged to cut about one-eighth inch kerf. Most of the larger mills are now using the band saw, whereas the smaller mills, especially those that are portable, are equipped with circular saws. There are a great many more circular-saw mills in operation than band-saw mills, but the amount of lumber cut by the two classes of saws is probably the same. The average kerf may, therefore, be assumed to be three-sixteenths of an inch.

An idea of the enormous waste in kerf may be obtained from the following figures: The total production of lumber in the United States during 1907 was approximately 40,250,000,000 feet. The kerf on this lumber, assuming that all of it was cut into 1-inch boards, is equivalent to over 7,500,000,000 feet. To obtain this amount of lumber it would be necessary to cut over an area of about 1,250,000 acres of forest, running 6,000 board feet to the acre, an area almost as great as that of the entire State of Delaware. Figuring that the average annual growth of lumber is 300 board feet per well-stocked acre—a most liberal assumption—the annual loss due to kerf represents the yearly growth of forest on 25,000,000 acres, an area equal to that of either Virginia or Kentucky. That is, if either of these States were covered with an unbroken growth of timber, the annual growth in such a forest would be just enough to compensate for the sawdust.

Since sawdust is, in most cases, used to furnish the fuel to run the mill, it is not an absolute loss. However, with the modern fuel-saving burners the supply usually is in excess of the requirements of the mill. Besides, it is poor economy to convert good lumber into sawdust, even if it is used for fuel, and any saving of waste from this source is greatly to be desired. In a few cases, also, a small portion of the sawdust is sold for packing, stable flooring, etc. It will now be shown that part of this waste is unnecessary and quite avoidable.

The kerf really consists of two parts—the actual width of the sawteeth and the swage of the saw. As mentioned above, the average

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circular saw used for sawing logs is 8-gage. This represents a thickness of 0.165 of an inch. The actual kerf for such a saw is 0.25 of an inch, the extra 0.085 of an inch being due to "setting" the saw in such a way that it will allow for a proper "clearing" of the log—in other words, to allow space in the cut for the sawdust, and prevent the blade of the saw from binding against the cut surface. Similarly a band saw of 14 to 16 inch gage, representing a thickness of 0.072 of an inch, cuts a kerf of 0.125, an allowance of 0.053 of an inch for "clearing" the log. At least part of this allowance is quite unnecessary. The saving in lumber which may be effected through careful filing and setting is considerable. It probably represents no less than 0.03 of an inch in each cut, or about 3 per cent of the lumber cut.

Unnecessarily thick saws make unnecessary waste in kerf. This brings up the much discussed question of the relative merits of the band and the circular saws.

The claims that have long been put forward in support of the circular saw are that it can be fed faster, that it requires less power, that it is more easily set up and kept in order, and that it does not need the skillful attention required by the band saw. Recent investigations show that these claims have been greatly exaggerated; in fact, that some of them are baseless. It is now generally conceded that in large logs the band saw will cut more lumber in a given time than will the circular, and that the band saw uses less power than the circular saw, doing the same work.

The main point, however, in favor of the band saw is the great saving in lumber which it makes possible. The following table, based on a mill tally of 5,177 white-pine logs cut with a circular saw and 767 white-pine logs cut with a band saw, shows the number of board feet of lumber obtained per cubic foot of peeled log. The lumber was not edged, but was sold "waney" or round edged.

TABLE 1.—*Board feet per cubic foot of peeled log (round-edged lumber).*

Diameter inside bark at small end of log.	Cut with a circular saw.	Cut with a band saw.	Diameter inside bark at small end of log.	Cut with a circular saw.	Cut with a band saw.
Inches.	*Board feet.*	*Board feet.*	*Inches.*	*Board feet.*	*Board feet.*
5	5.5	6.5	13	7.4	8.5
6	6.0	6.6	14	7.5	8.6
7	6.4	6.6	15	7.5	8.6
8	6.7	6.8	16	7.5	8.6
9	6.8	7.3	17	7.6	8.8
10	6.8	7.5	18	7.7	9.0
11	6.9	7.8	19	7.7	9.0
12	7.2	8.2	20	7.8	9.1

The conditions in the mills where the lumber was tallied, on which the above table is based, were very similar, and the difference between the relative amounts of lumber obtained is due almost entirely to the difference between the thickness of the saws.

The saving effected by the band over the circular saw is usually estimated by lumbermen to be 10 per cent of the possible lumber cut. Assuming, as before, that one-half of the 40,000,000,000 feet of lumber produced last year was cut with a circular saw, the saving of 10 per cent would represent a saving of 2,250,000,000 feet (the 20,000,000,000

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feet representing only 90 per cent of the amount of lumber obtainable), or the annual growth on over 6,500,000 acres of forest at 300 board feet per acre.

In addition to the loss caused by an undue amount of sawdust, the circular saw entails a loss from another source. The width of the widest board which such a circular saw can cut is equal to the radius of the saw, less about 3 inches (allowed for the collar of the saw). For this reason, even where a 54-inch saw is used, no log greater than 24 inches in diameter can economically be cut with it. When a larger log comes into the mill it is turned on the carriage and slab after slab is pared away until the log becomes small enough for the saw to cut through it completely. This involves not only an enormous waste of the best lumber in the log, but also a great waste in labor. In many instances the plank or slab is only partly separated from the log, and axes are used to cut it off completely.

Measurements made in a mill cutting western yellow pine in New Mexico indicate that the loss of lumber from the use of circular saws too small for the large logs was from 3 to 5 per cent of the entire output of that mill. The loss in value was even greater, since the wood wasted is the clearest lumber in the log. An idea of the time loss may be obtained from the following instance: A log 36 inches in diameter came into the mill. It was figured that under favorable conditions it should have taken from twelve to fifteen minutes to saw it up. The actual time consumed from the time the log was put on the carriage until the last board was taken away by the off-bearer was a little over forty minutes, a loss of at least twenty-five minutes, and for more than an hour afterwards the mill was littered with slabs and chips, and smooth, efficient work was prevented. No definite figures of the loss from this source can be given for the entire country.

Prof. C. A. Schenck arrives at the following conclusions in regard to the relative merits of the band and the circular saws:

> The superiority of the band over the circular saw lies in a saving of 1,000 board feet in every 16,000 feet of -inch boards obtained. The boards have a better width. Logs over 4 feet through can not be handled by circular saws. Further, the band saw allows of a more rapid feed.

The band saw has come into general use in the bigger mills, but the vast majority of mills cutting less than 2,000,000 to 4,000,000 feet a year—in other words, the majority of the small and portable sawmills—are still using the thick circular saws. The main reason for this fact is that it is easier and cheaper to equip a mill with circular saws than with band saws.

The additional waste due to thick saws takes place at the mill, and the loss represents not only a loss in the cost of stumpage, but also a loss in logging and bringing the logs to the mill. In short, it is not only a waste of lumber, but also a waste of labor. With these facts in view, it is only a short time before the band saw will replace the circular saw in all but the very smallest operations.

Mr. Austin Cary, who has been investigating the practicability of the use of portable band-saw mills, has the following to say on this subject:

> The saving in lumber secured by the use of band saws in place of the thicker rotaries is well known. It is usually reckoned by lumber operators as 10 per cent of the cut.

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The band saw from the operating point of view is also satisfactory and effective. It uses less power than a rotary doing the same work. It does true and satisfactory sawing if set up right, not overspeeded, and properly handled. As a stationary mill it is for many purposes considered the best and it is securing something of a field in use as a portable. The chief difficulties in its use arise in connection with keeping the saws in order. Much more skill and equipment are required than in the case of the rotary.

Light band mills are employed as portables to some extent in New England and in the South. This paper is written with a view to their use in the western forests.

A type of mill in use for this purpose at the present time carries saws 8 inches wide and 33 feet long, of 16 or 18 gauge thickness, swaged to cut three-thirty-seconds inch or less. The wheels are 5 to 5½ feet in diameter, the upper one adjusted to maintain an even tension at all times. The saw frame entire weighs in different makes from 6,000 to 10,000 pounds, but in transportation is practically taken apart, so that the weight of the heaviest single piece is only about 2,000.

Firm setting is essential to cheap and smooth running and the production of well-sawed lumber. This may commonly be secured by means of posts set in the ground to which the timbers of the mill frame are fastened. If this does not in any case give sufficient firmness, the frame may be further fixed by bracing timbers rising from the ground or timber frame to a bearing on either side at the level of the upper journals.

The carriage and accessories for a mill of this type are very nearly the same as for a rotary used as a portable, an offset to free the saw from the log in gigging back being the only difference. The mill is furnished at the factory with carriage complete up to 20 feet long, set works, friction and cable feed, standard track and wheels, set shaft, and receder for about $1,600. This is about twice the cost of the same equipment for a rotary. An equipment of 6 saws costs $240.

CAPACITY AND POWER.

This mill can cut up to 25,000 feet a day, but run as a portable 10,000 to 15,000 may be counted as its capacity, according to quality of logs. To run such a mill on pine logs, engine capacity of 35 horsepower net is found to be sufficient. An edger requires 10 horsepower additional and a wide planer 25. A 50 horsepower engine of good make with boiler of one-third greater capacity costs in the neighborhood of $1,200. With large logs considerably less power is required to cut the same amount of lumber with the band than with the rotary. With small logs, the rotary requires less power.

FILING ROOM.

It is customary when using the band as a portable to construct a small shanty for filing near the mill, with steam pipe from the main boiler running a small filing-room engine. Where the mill is longer in one place the filing room may be built in the roof of the mill and the machinery run from its shafting. The equipment required is as follows: Automatic saw sharpener, stretcher, adjustable stand and pulleys, filing clamps, shears and retoother, automatic lap grinder, forge, brazing table, swage, shaper.

Total cost of these tools about $600. Total weight about 3,000 pounds. This outfit embraces all that is required to do the fitting and filing by machinery. The outfit may be lessened if certain parts of the process are done by hand.

KEEPING IN ORDER.

A good-sized outfit of saws, six being desirable, is the first requisite for successful employment of the band saw. One set of three may then be kept constantly in order and in reserve for emergencies, while the other three are in use and subjected to minor repairs. Experience and skill are both required to keep a band saw in order. Condition has to be more carefully kept up than in a rotary, though there is this advantage—that apparently bad accidents, such as would destroy entirely the value of a rotary, may be repaired on the spot in case of a band by means of the shears and retoother. Filers for band saws uniformly draw good wages, though good work here pays in quality and output of lumber. It is not necessary, however, to have a special filer for a portable band mill in most circumstances, as the sawyer may occupy this post also, mak-

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ing small repairs to his saws at noon or night and heavier repairs at slack times or between settings. This arrangement has been successfully worked in Massachusetts, and the running cost of operation of a band mill in consequence kept very close to that of a rotary.

TRANSPORTATION.

A band mill for portable use requires the transportation of from three to four tons more than a rotary employed in the same work. There is extra cost involved also in setting up the mill, as earlier explained. In fact, in Massachusetts practice the cost of moving a short distance and setting up is reckoned at twice that for a rotary. This enlarged cost does not hold in the same ratio on long moves, and the larger the amount of lumber to be cut at one setting, the more advantageous the band mill. For set-ups of under 500,000 the band as against the rotary can not be considered on ordinary lumber as practicable. When the amount to be cut is a million or more, the band is considered in Massachusetts advisable. On high-grade, valuable timber the saving secured by the band saw is a far more important matter and smaller set-ups can be profitably handled.

CONCLUSIONS.

The band mill cuts lumber out of anything but the smallest logs with a third less power than the rotary.

It saves 10 per cent or more of the lumber cut, whatever the value of this may be.

The initial expense of a band mill for portable use is greater than a rotary, the figures for the two outfits complete being approximately $2,500 and $4,000.

The band mill is more expensive to move and set up. This makes it impractical for very small amounts of timber.

The band mill requires more skill to keep the saws and machinery in order, but by good arrangements the extra cost of this work may be kept down very low.

Altogether the use of the portable band seems to promise considerable saving and efficiency in the utilization of the timber of the national forests.

When band saws first came into vogue and the advantage of narrow kerf was seen, efforts were made to make the saw thinner and thinner. Experience very soon showed that when the steel reached a certain degree of thinness it did not possess the rigidity necessary to cut straight lumber. But even after this limit was reached a further reduction can be made in the kerf by the introduction of the resaw.

The resaw is either a circular or, more often, a band saw of very narrow gage, and is used to resaw thick lumber cut with the heavier primary saws. There is a double saving in the use of a resaw, a saving in lumber and a saving in the labor of the highly paid sawyer. A skillful sawyer receives from $5 to $10 a day. The grade of labor commonly employed on a resaw is paid from $2.50 to $4 a day. Where a resaw is used the log is cut into thick plank by the skillful sawyer, who gets the greatest amount and the highest grades of lumber possible from the log, and the thick plank is then resawed by the lower-paid resaw man. This is an ideal arrangement, and the millmen are fast beginning to realize it. Out of a total annual cut of 7,121,000,000 feet reported from 540 mills, 4,130,000,000 feet, or 58 per cent of the total, was resawed. The percentage of lumber resawed in the entire country is, however, probably less than 58 per cent of the entire output, since the mills reporting were mainly large mills, and resaws are mostly employed in large mills.

On the other hand, possibly one-fourth of the above named lumber was cut with gang saws. The waste due to gang saws is very large because of the high percentage of lumber which is converted into slabs. The main advantage of the gang saw is the rapidity with

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which it works. Although no definite data are available it is safe to say that the waste in lumber offsets this gain. It takes little figuring to prove this point. Assuming that the value of the log on the carriage before it is cut is $7.50 a thousand board feet, and that the average wage is $2.50 a day per man, the money represented by a waste of only 1,000 board feet will pay the wages of 3 men for a day. With the extra waste due to the gang saw figured at 10 per cent of the actual cut, a mill with a gang capacity of 100,000 feet a day can afford to employ 30 extra men a day instead of the gang saw. It is very doubtful whether the gang saw saves that much labor.

WASTE DUE TO SLABS, EDGINGS, AND TRIMMINGS.

Probably the heaviest waste in a sawmill is in slabs, edgings, and trimmings. This waste is due to the circular form of the logs, to their surface irregularities and to their natural crook or "sweep." The amount of it depends on a number of factors:

1. The species and age of trees cut. Some species are much more cylindrical and regular in shape than others. Older trees are usually fuller and less tapering than young trees.
2. The position of the log in the tree. The top and butt logs of most species are more tapering than the middle logs.
3. The skill and care of the sawyers in the woods. Judicious division of the tree into logs will largely eliminate crooks and defects.
4. The length of the shortest board considered merchantable.
5. The value of lumber as compared with freight rates. Where lumber is comparatively cheap, while freight rates are high, there will be more slabs and short boards wasted than would otherwise be the case.
6. The care exercised by the sawyer and the other mill hands.

For convenience in describing the waste in slabbing, (1) loss in edging and trimming and (2) loss in slabs will be considered separately.

LOSS IN EDGING AND TRIMMING.

Prof. Judson F. Clark, who, while constructing his International log rule, had occasion to study the question of loss of lumber in edging, states the following conclusions:[a]

1. Edging waste remained practically constant regardless of the width of kerf cut by the saw.
2. It was found that the waste due to crook (major and minor) of all degrees was in direct proportion to the circumference of the logs sawn; i. e., the waste due to any particular degree of crook in a 20-inch log was practically double that caused by a similar amount of crook in a 10-inch log.
3. When provision is made in the scaling score for an average taper of 1 inch per 8 feet linear, and when the logs show an average major crook of 1¼ inches per 12 feet, the necessary allowance for edging waste as above defined was found to be 0.8 foot board measure per square foot bark surface for white-pine logs of all dimensions.

The effect of increasing major crook on the product of sawn lumber was also studied. The results of such a study depend directly on the size of the smallest board which is regarded as merchantable by the investigator, for with increasing crook there is a greatly increased output of short lengths sawn from

[a] "The measurement of saw logs," by Judson F. Clark, in Forestry Quarterly, Vol. IV, No. 2, pp. 84–85.

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the heavy slabs. The rules of the National Hardwood Lumber Association, the Louisiana Cypress Association, and other similar bodies have set the minimum dimensions of boards entitled to pass inspection and measurement in the case of most species at 3 inches in width by 4 feet in length. Using a minimum unit of just double this size I found that as logs were cut for ordinary commercial purposes in the mill in which I made my tests, an increase in the average major crook of 1 inch per 12 feet increased the allowance required for edging 0.1 foot board measure per square foot of bark surface. With a minimum unit of 3 inches in width by 12 feet in length the additional waste in edging for the same increase in average crook was just threefold, or 0.3 foot board measure per square foot of bark surface.

Although no more definite data than those given above are available on this subject, yet a fair idea of what this loss amounts to may be gathered from Table 2.

TABLE 2.—*Waste in slabs, edging, and trimming.*

Diameter at small end of log, inches.	Edged and trimmed yellow poplar.			Unedged and untrimmed white pine.			Per cent of peeled log wasted, presumably in edging and trimming.
	Board feet per cubic foot of peeled log.	Per cent of peeled log used.	Per cent of peeled log wasted in kerf, slabs, edging, and trimming.	Board feet per cubic foot of peeled log.	Per cent of peeled log used.	Per cent of peeled log wasted in kerf and slabs.	
10	6.6	55	45	7.5	63	37	8
11	6.7	56	44	7.8	65	35	9
12	6.7	56	44	8.2	68	32	12
13	6.7	56	44	8.5	71	29	15
14	6.9	57.5	42.5	8.6	72	28	14.5
15	6.9	57.5	42.5	8.6	72	28	14.5
16	7.1	59	41	8.6	72	28	13
17	7.1	59	41	8.8	73	27	14
18	7.3	61	39	9.0	75	25	14
19	7.3	61	39	9.0	75	25	14
20	7.4	62	38	9.1	76	24	14
25	7.6	63	37	.....	.....	.....	.....
30	7.7	64	36	.....	.....	.....	.....
35	7.8	65	35	.....	.....	.....	.....
40	7.9	66	34	.....	.....	.....	.....

The foregoing table is based on yellow poplar logs which were edged and trimmed at the mill, and on white pine logs which were neither edged nor trimmed. The logs in both cases were sawed with a band saw. The difference in the percentages of waste is presumably due to the waste incurred in edging and trimming. It is seen to vary from 8 per cent for the smaller logs, which are most wasted in slabbing, to 14 per cent in the larger logs.

Since the old yellow poplar is much more cylindrical than the second growth white pine, the loss in slabs, edging, and trimming should have been relatively less in the former than in the latter species. It is, therefore, safe to assume that the minimum waste incurred in squaring boards is 14 per cent of the peeled logs; a very conservative estimate would place it at 10 per cent. This is equivalent to a loss of about 4,500,000,000 board feet in the 40,250,000,000 board feet of lumber cut in 1907.

There is very little unedged timber sold in the United States—in all probability less than 10 per cent of the total output. Deducting 10 per cent from the 4,500,000,000 feet figured above, still leaves over

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4,000,000,000 feet lost annually in edging and trimming. Assuming an annual growth of 300 board feet per acre, it would take a solid forest of 13,333,333 acres to produce the lumber wasted annually in squaring boards. This area is almost as great as the combined territory of Vermont, New Hampshire, and Connecticut.

There is no doubt that a portion of this loss is quite necessary and unavoidable, and where this is true, if the loss did not occur at the mill it would be transferred to the consumer or woodworker. Nevertheless, by far the greater portion of the waste is due to the cheapness of the wood when compared with freight rates, and to usage or custom.

A very heavy waste in the manufacture of lumber is caused by standardizing lengths and widths of boards. It is a general requirement of the lumber market that the lengths of boards shall be in multiples of 2 feet. Odd lengths, such as 9, 11, 13 feet, etc., are not admissible except in special orders. The result is that much good lumber is lost through trimming.

A piece of lumber may have a defect at one end making it a few inches shorter than a certain standard length. The board is trimmed down to the next lowest standard length, with a loss of almost 2 linear feet of board.

Similarly with the widths of boards. It is customary with certain kinds of wood, such as white pine, western yellow pine up to 16 inches in width, western larch, etc., to cut the boards in widths which are multiples of 2 inches. With other species, however, as with most of the eastern and southern hard woods random widths are admissible.

The lengths of boards can, to a large extent, be regulated by the sawyers in the woods; i. e., the sawyers can divide a tree without great loss into logs of standard lengths. But the width of boards can not be so regulated. It follows from the law of averages that in the long run the loss in width will be 1 inch when the standard widths are multiples of 2 inches, or one-half inch when the standard widths are consecutive inches. With the average board sawed 12 inches wide this loss would represent a waste of from $4\frac{1}{6}$ to $8\frac{1}{3}$ per cent of the lumber cut, in addition to loss incurred in edging off the wane. This waste is unnecessary and inexcusable.

What the exact loss is through this source—trimming to standard lengths and widths—it is, of course, impossible to say, but it is possible to make a rough estimate. A study of the grading rules adopted by the various lumber manufacturers' associations brings out the fact that about one-third of all the lumber manufactured is cut into standard widths. Assuming a loss of three-fourths of an inch in width, the average between a loss of 1 inch for even inch widths and one-half inch for consecutive inch widths, and an average width of board of 12 inches, the loss last year due to standardizing widths was at least $2\frac{1}{2}$ per cent of the total output, or a little over 1,000,000,000 board feet of lumber. Two per cent will be taken as the working estimate.

LOSS FROM SLABS.

In addition to the loss in edging and trimming, and closely allied to it, is the waste in slabs. The factors which influence this loss have already been stated. The seventh column in Table 2 indicates the

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percentage of the peeled log wasted in kerf and slabs. The percentage of kerf is fairly constant for logs of different sizes, and in Table 2 amounts to 11 per cent of the volume of the peeled log.[a] Subtracting 11 from the value given in the column leaves the percentage of the volume of the peeled log converted into slabs. This is seen to vary from 26 per cent for a 10-inch log to 13 per cent for a 20-inch log, the percentage of waste decreasing as the size of the log increases. The average log sawed in the United States is probably less than 20 inches in diameter. This would indicate a minimum waste of 13 per cent in slabs alone. To be conservative this figure will be reduced to 10 per cent of the peeled log, or a total loss of 4,474,000,000 feet for the lumber produced in 1907.

This loss arises mainly from the fact that short and narrow boards can not now be utilized as lumber. In a number of mills observed in various parts of the United States the shortest board that it pays to ship is 8 feet long. The narrowest admissible width is usually 3 inches. Shorter or narrower boards are either cut as lath and batting, or else are used as fuel or burned in the slab burner.

To summarize: There is lost annually through edging and trimming about 10 per cent of the total possible output. An additional 2 per cent of the volume is lost through standardizing sizes, while at least 10 per cent more is lost through slabs, a total loss in slabs, edging and trimmings of 22 per cent.

All of this waste is not an absolute loss. A large part of the slabs and edgings is used for making lath, and in so far as the edgings and slabs are of such size and form that they can not be utilized for any better purpose, their conversion into lath should not be considered a waste at all. To put it differently, the country requires a certain number of lath. This lath can be very economically manufactured from slabs and edgings at a sawmill. As long as the slabs and edgings are more useful for lath than for any other purpose, there is no waste entailed, but a waste occurs when material better fit for lumber is converted into lath.

The production of lath in 1907 was 3,663,600 thousand pieces. It is generally assumed by lumbermen that on an average 1,000 lath can be produced for every 3,000 to 4,000 board feet of lumber manufactured. Assuming that all the lath produced in 1907 was made from slabs and edgings (and there is no doubt that a large percentage of it was cut from logs and bolts), it would have taken an output of only 14,654,400,000 board feet of lumber to yield as a by-product all the lath required by the country last year. This still leaves a waste of the edgings and slabs from over 25,500,000,000 feet of lumber, or from two-thirds of the lumber produced in 1907. A part of the waste, and probably a very small part of it, was converted into pickets and battings, but the fact still remains that about one-half of the slabs, etc., representing a potential output of over 4,500,000,000 feet of lumber was wasted. A part of it, perhaps the larger, was burned under the boilers at the mill, but its use as fuel is very small, when compared with its value as lumber, and the consequent loss entailed is heavy.

[a] The lumber was cut with a band saw removing one-eighth inch kerf. The loss in kerf was therefore 1 inch for every 8 inches of boards sawed. This is equal to one-ninth or 11 per cent of the volume of the peeled log.

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That a large portion of the waste in trimming to standard lengths is quite unnecessary may be gathered from the fact that the average length of all the pieces of lumber in the ordinary house, including timbers, flooring, sheathing, siding, finish, casings, base, doors, windows, frames, etc., but not including lath and shingles, is less than 4 feet. The average length of all lumber used for every purpose, including the building of bridges, ships, docks, railroads, fences, boxes, houses, etc., is still under 4 feet. Thus large quantities of lumber longer than the average piece used are being used for fuel, because the pieces are considered too short.[a]

Lumbermen throughout the country are fast beginning to appreciate the enormous waste which accompanies the manufacture of lumber, and there is some hope that savings will be effected all along the line. It may not be out of place to give the following extract taken from a paper read by George W. Roper, general manager of the John L. Roper Lumber Company, Norfolk, Va., before a meeting of the North Carolina Pine Association, and reported on page 40 of the American Lumberman for April 7, 1906.

According to our present method of inspection and grading and under our general rules we are not permitted to ship as merchantable lumber in the rough pieces which are shorter than 10 feet, and are limited to a certain percentage of this length.

I do not believe that the time has yet come in which we can make our merchantable lengths 12 inches and up, but I believe that we can just as well sell No. 1 and No. 2 strips 4 feet and up in length as some others can sell their product in even shorter lengths. When I say 4 feet and up, I do not mean 4, 6, 8, 10, etc., but mean lengths of 4, 5, 6, 7, 8, etc. The barbarous idea, originated by us possibly, of cutting off a board 2 feet in order to cure a 6-inch defect at the end should not, in my judgment, be longer tolerated. There is no reason in the world why the trade would not accept 11, 13, and 15 foot boards as well as 10, 12, 14, and 16. Then, again, if we were allowed to use short lengths could we not often in our woods secure an 8-foot log at the top of the tree which now is lost?

I understand that, in some other classes of wood, there is a grade known as "shorts"—being lumber in lengths of from 4 to 10 feet. This lumber, I am told, is sold log run, or used to be sold that way, for about three-fourths as much as the usual log run, exclusive of the shorts. If we could adopt as our standard lengths for Nos. 1, 2, and 3 lumber 4 feet and up in multiples of 1 foot, and in box grades adopt similarly 6 feet and up, we could expect to get from our sawmills an increase output on an average from our logs sawed about 5 per cent. With a mill cutting 60,000 feet of lumber a day, situated at Tidewater, Va., and assuming the average value of the output a thousand to be $20, which is considerably under that obtained by us at present in my judgment, we would be enabled to gain $60 a day which now is lost. Assuming the mill ran two hundred and fifty days in the year there would be an actual saving of $15,000, which is 6 per cent on an investment of $250,000. If the mill plant is worth $60,000, the saving would represent 25 per cent on the plant investment or the cost of the plant.

Some of our mill plants are making steam now with lumber which ought to be worth $15 a thousand, if we got no more for it than edge-box price. A great many of our mill plants are putting the clearest of their lumber into the slabs, because we do not have a rough-lumber grade which will admit short, clear boards. The clearest lumber that we get is that which is located nearest the outside of the log, and anything that we can do to reduce the merchantable lengths of No. 1 and No. 2 will not only increase the quantity of lumber that we can get out of a log but will also largely increase the percentage of No. 1 and No. 2 lumber.

Two or three of our mill plants, at the request of the writer, have made some experiments in cutting up 12-inch box, edge box and mill culls, in order to

[a] See "Looking back on lumber waste," in American Lumberman, August 1, 1908, p. 45.

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determine what percentage of No. 1 and No. 2 lumber especially could be secured in shorter lengths, if this lumber was remanufactured with this end in view. From these experiments we have found that in cutting up 12-inch box we obtained over 450 feet of No. 1 and No. 2 lumber, and out of about a thousand feet of 12-inch box there were only, approximately, 175 feet of lumber which should have remained in 12-inch box, or, in other words, only 175 feet out of the thousand did not justify remanufacture. The value of the No. 1, 2, and 3, etc., obtained from a thousand feet of 12-inch box, assuming that we had sale for it, in lengths of 4 feet and up, was very close to $22. The value of 12-inch box is $18.50. This lumber can be remanufactured at a cost certainly not exceeding $1.50, which would leave a clear profit of $2 a thousand to the manufacturer, or 10 per cent, approximately, more than he gets for his lumber now.

In the case of edge box, in the experiments which I had made I found that saving, much to my surprise, even greater than in 12-inch box. Cutting up the edge box in a similar manner to that of the 12-inch there was obtained out of a thousand feet $19.40 worth of lumber, according to the list price. The value of that amount of edge box would have been $15. Adding $1.50 for the cost of manufacture would still leave the manufacturer a profit of $2.90 a thousand on his edge box thus remanufactured, or a clear profit of approximately 20 per cent.

Cutting up a thousand feet of mill culls in a similar manner yielded lumber to the value of $19. Mill culls, I believe, are worth $13 a thousand feet. Adding to this the cost of remanufacture and subtracting from the above would leave a profit of about $4.50 to the manufacturer due to remanufacturing his cull lumber, or a saving of over 30 per cent. The question arises right here, How far can the present North Carolina rough-pine manufacturer enter into the details of cutting up his lumber, and will it pay him? Is it better for him to manufacture a trifle less lumber and get much better returns per thousand feet? Are we not in many instances getting out in our sawmills quantity at the expense of quality, grade, and value of output? These are all serious questions for consideration and there are hundreds of others which I will not mention. If we continue to put our No. 1 lumber into slabs in order to feed it to a hog, that it may furnish steam for our plants, or cut off 2 feet from the end of a 16-foot No. 1 stock because of slight blemish at the end or on account of the log having been cut an inch too short in the woods, there is no law that I know of to prevent this crime! In my judgment the average of us are wasting 5 per cent of the output of our logs, according to present methods. Is this worth anything to us? Are we so prosperous that it does not make any difference?

Practical forestry is beginning to be recognized in our section of the country, and all eyes at this time seem to be turned to the trees which are being fast cut down—the timber resources of the country are being exhausted rapidly. Measures are being taken to replenish in part at least this vast quantity of lumber cut. This is a very commendable movement and one which should receive the encouragement of our association. At the same time would it not be wise for us to undertake to get from the trees which we do cut down in the course of our business all of the lumber that we possibly can, and utilize every portion of them that we reasonably can? As timber grows scarcer such portion of the log as heretofore was waste will be more and more utilized. This condition will necessarily cause many of us to remodel our ancient plants in order that we may not be required to use merchantable lumber in the furnaces to make steam. In olden times the waste was at a maximum. Our forefathers did not begin to use any portion of the wood until they reached the heart. We have increased that portion of the log which is salable until we have almost reached the bark. In many classes of goods which are manufactured now the bark itself is being utilized, and in many places the sawdust as well.

[NOTE.—The figures with reference to the value of lumber used in this article are based on the price list of December 12, 1905. Since that time an increase in the price of lumber simply magnifies the results obtained, as shown.]

WASTE DUE TO CARELESS MANUFACTURE.

The loss in kerf, slabs, and trimmings constitutes by far the heaviest waste in converting logs to merchantable form. At least a portion of this waste is absolutely necessary and should not there-

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fore be considered a waste at all. But there is another source of loss which is unnecessary and which can be easily avoided. This is the loss due to carelessness in manufacture. Hardly any process in the mill is free from it, and when taken for the entire country the waste which occurs is extremely heavy. No definite figures can be given on this subject, but an effort will be made to show how the waste occurs.

In most sawmills when the log reaches the log deck it is put onto the saw carriage by means of "kickers" and "loaders." These are usually iron or steel bars of various shapes, often terminating in sharp points or edges. It frequently happens that logs are broken outright by a careless manipulation of these tools. More often holes are gouged in the sides of the logs, which, although not serious when the bark is still on the log, may entail a considerable waste when the logs come into the mill peeled.

The "nigger" is another frequent cause of waste. The "nigger" is used to put and to turn the log on the carriage. It is a long steel bar or rod fitted with sharp hooks. Unless carefully manipulated the hooks tear the lumber in the log, especially after the log is squared. It often happens when the "nigger" does not work smoothly that the sawyer impatiently pushes it up and down an unnecessary number of times, and violently and repeatedly slaps the log with it. In such cases there is a considerable loss of lumber, for the torn surface of the plank or log must be cut off and thrown on the slab pile, unfit even for lath.

A very heavy loss is caused by setting the log carelessly on the carriage. Most set works are manipulated by means of ratchets. A pin quadrant or scale is attached to a circular slide close to a set lever, graduated in sixteenths of an inch, and having a hole opposite each graduation. A pin inserted in the one indicating the thickness to be sawn limits the travel of the lever, and correspondingly the movement of the set beam of the carriage and the log. After the set works have been used for some time and the machinery becomes more or less worn, one or both of the following things may happen: The hole becomes worn, so that the pin does not fit snugly but gives with the manipulation of the lever; or the pin becomes worn, with the same result. The effect is to move the setting beam too far and to cut the boards thicker than intended. This extra thickness is a total waste, since it is dressed off at the planing mill. The waste is cumulative and may amount to from 3 to 5 per cent of the output. This loss can be obviated by a frequent inspection of the machinery.

The effect of careless sawing, edging, and trimming is admirably stated by E. A. Braniff.[a]

> The profits of milling depend to a considerable extent upon the sawyer, the edgerman, and the trimmer. Many mill owners make the mistake of gauging their sawyer's ability entirely by his speed. It is he who sets the pace for the mill crew and they must keep up with him; therefore every extra thousand feet cut reduces the average milling cost. Broadly speaking, however, what the average sawyer gains in speed above the normal cut he loses in the quality of his product, especially if he is sawing valuable timber, such as yellow poplar. In order to get the best results the sawyer must take time to look at his log and turn it on the carriage as often as necessary. The sawyer whose sole

[a] "Grades and amount of lumber sawed from yellow poplar, yellow birch, sugar maple, and beech," Bulletin 73, Forest Service, pp. 21–22.

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aim is to make a big cut is the most expensive man the mill owner can employ for the work.

Rapid sawing necessitates rapid work at the edger and trimmer. Much may be lost by inefficient men at these machines. They handle several thousand boards every day, each of them a separate problem which must be solved instantly. The loss of 1, 2, or 3 cents on a piece of lumber by improper edging or trimming is not much in itself, but when these mistakes accumulate, the aggregate per day is often enough to pay the workman's wages several times. The edgerman has no time to stop and make calculations for each separate board. He stands in front of a stream of boards which he must feed into the machine as fast as the live rollers bring them to him. He can, however, be made so thoroughly familiar with the principles of his work that a glance at a board as it comes to him will usually be enough to tell him what to do with it.

The loss entailed in working night shifts and the waste incurred in unduly large mills are closely allied to the waste due to carelessness.

It sometimes happens that owing to a special rush order, or because the logging operation is far ahead of the milling operation, a night shift will be put in the mill for the emergency. In such cases, since it is almost impossible to obtain a complete crew of mill hands for a short time, the regular crew is split up, with the result that the night shift consists mostly of second-class men, while both shifts run short handed. The regular setter then becomes the sawyer, the dogger takes the place of the setter, the slab cutter may be advanced to the position of trimmer, and so with the rest of the men. The waste which occurs through such an arrangement is very great, for not only are the hands not expert enough to do the work, but the fact that the crew is smaller than normal adds to the waste and the confusion. In one mill observed it was estimated that the waste caused by putting on a double shift for two weeks amounted to about 15 per cent of the total output for the two weeks' night work.

Some mills work a double shift regularly, and the loss is not so great. Still even here the listlessness of the night workers will cause greater waste than would be the case with an all-day crew, besides an output of more poorly manufactured lumber.

It is generally assumed by mill men that lumber can be manufactured $2 per thousand cheaper by working double shifts, because with a given fixed capital there is a double output. This assumption does not take into consideration the additional waste and the additional wear and tear on the machinery which, in the long run, may nearly offset the gain.

It is now conceded by most mill men that very large sawmills are not economical, i. e., it pays better to operate two medium-sized mills than a single large mill, since it is difficult to take care of the output of the large mill. The waste of lumber at a large mill is proportionately greater than in a medium-sized one.

The waste caused by carelessness in manufacture, by working night shifts, and by the operation of unduly large mills, when taken for the entire country may be very conservatively placed at 4 per cent of the total output, though, from its very nature, no definite data can be collected on this subject. As already said, this waste is unnecessary; it is mainly an absolute waste, although a small portion of it may be utilized for lath and shingles.

WASTE IN GRADING.

The bulk of all the lumber manufactured is graded by standard rules, adopted by the various lumber manufacturers' associations.

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The difference in value between two consecutive grades varies from $3 to $10 or more per thousand feet. According to present grading rules the class of a board may be increased one or two grades by a judicious trimming or edging. In other words, the actual money value of a board is increased if part of the board is cut off and thrown away. To take a specific example: A yellow poplar board 16 feet long and 21 inches wide, containing 28 board feet, has, besides a few small scattered knots equivalent to two standard defects, one large knot about 8 inches from one end. According to the grading rules of the National Hardwood Lumber Association the board will be classed as No. 1 common, and be worth, at $23 per thousand board feet, a little over 64 cents. By trimming off the large knot and (according to the standard length rule) reducing the board to 14 feet in length, containing 25 board feet, the board is raised to the firsts and seconds grade, which commands a price of $44 a thousand for boards more than 18 inches in width. The value of the board is now $1.10. By sacrificing 3 board feet the value of the board was almost doubled. Yet the board was not really changed in character, and nothing was added to it which it did not already have. On the contrary, part of a board having in itself some value was thrown away. This is perhaps an extreme case, but illustrates admirably the heavy premium put on waste by the present grading rules. The waste due to this source was included in the loss through edging and trimming. It is emphasized here merely to indicate a possible saving. There is no doubt that the loss amounts to from 3 to 5 per cent and can be entirely saved. Pressure should be brought to bear on the grading bureaus of the various associations to revise their rules so that no premium will be put on waste of lumber.

THE LOSS OF THE WASTE.

So far, the question of waste has been considered chiefly from the point of view of lumber production. That is, if a portion of log fit for lumber were converted into sawdust or slabs, it is classed as waste. Such may be entirely necessary, as in the case of a certain minimum percentage of kerf without which no lumber can be manufactured, but in so far as it is converted into sawdust when it might have made boards and plank. All kerf is waste of lumber (it is an actual, though necessary waste). It is now in order to consider the loss of this waste material.

Sawdust is almost a total waste. Most of that which is used is as fuel under the boilers; part of it goes into the slab burner; a very small fraction of it is sold for stable bedding, ice packing, etc. Of the cut of 7,121,000,000 board feet of lumber reported in answer to the circular letters already mentioned, only about 2½ per cent of the sawdust produced was used for other purposes than fuel. A large percentage of the sawdust is left in heaps in the woods because there is absolutely no demand for it. The question of utilizing the sawdust and waste slabs is discussed by Doctor Bristol in his report to the Commission.

As has already been shown, slabs and edgings are partly used in making lath. Most of them, however, as well as most of the trimmings, are used as fuel or are entirely wasted. This waste is not necessary. Part of the slabs should be sold as boards, while of the

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material unfit for lumber the greater portion should be utilized for purposes requiring small dimension stock. A long list could be given of articles which might be made from this waste, most of which are now being made from lumber better fit for other purposes; the more common articles are matches, toothpicks, excelsior, spools and bobbins, dowels, pail handles, clothespins, wooden dishes, toys, and novelties, the smaller sized packing boxes, shoe pegs, and skewers. The Forest Service is about to undertake a study of these industries with a view to suggesting a closer utilization of the present mill waste. It is not at all impracticable to use the slabs and edgings of certain species of wood, such as hemlock, spruce, etc., for pulpwood. The sawdust and slabs of other species, such as chestnut, chestnut oak, etc., may be used for the extraction of tannin. A small percentage of waste is already utilized in this manner, but much more can be used if only the mill men could get into touch with the tannin and pulp men.

WASTE OF BARK.

In the above calculations the waste is expressed in percentage of the volume of peeled logs. But the bark itself constitutes a large percentage of the log, and, since very little use has been discovered for bark, the loss of it may also be considered a waste. Table 3 shows the volume of the bark expressed in percentage of the total volume of the log.

TABLE 3.—*Percentage of bark in total volume of logs.*

Species.	Per cent.	Species.	Per cent.
Lodgepole pine	6	Chestnut [a]	13
Western hemlock	10	Red oak [a]	13
Eastern balsam	10.5	Yellow poplar [a]	13
White pine	11	Western yellow pine	15
Eastern (red) spruce	11	Douglas fir (second growth)	15
White oak [a]	12	Douglas fir (first growth)	20
Loblolly pine	13	Sugar pine	20

[a] Mostly estimated.

Hemlock bark has long been a valuable article of commerce, since it is extensively used in leather tanning. In fact, up to five or ten years ago in certain parts of the United States, the bark was the only portion of the hemlock used, for the lumber was not considered merchantable. Chestnut bark and the bark of certain oaks is also valuable for tannin. The bark of the other species of trees is, however, considered valueless and is left in the woods or sent to the slab burner.

WASTE IN MANUFACTURE OF VENEERS.

Statistics show that 348,000,000 board feet, log scale, were manufactured into veneering in 1907. Although very small when compared with the amount of wood manufactured into lumber, and only about one-fourth of the amount converted into cooperage stock, yet it represents the annual growth of a well-stocked forest of 1,160,000 acres, growing at the rate of 300 board feet per acre per year. The waste entailed in the manufacture of veneer is also very large, and a saving of this waste is greatly to be desired.

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Veneers are cut either with a saw or with a knife. If a knife is used, the veneer is either sliced or rotary cut. In the first case the log is usually stationary and the knife slices off thin layers of wood. If rotary cut the log is revolved slowly against a stationary knife. Answers received to a schedule of questions sent to the leading veneer men show that 88 per cent of all the veneer made in 1907 was rotary cut, 6 per cent was sliced, and 6 per cent sawed.

The chief sources of waste are as follows:

1. Defective ends on the logs cause ragged edges on the veneer, which must be cut off. This waste, as reported by the veneer men, amounted to 3.5 per cent of the lumber used.

2. Checks and cracks are serious defects, since it is almost impossible to use such logs for veneering. The waste from this source is 6 per cent of the lumber used.

3. Damaged sap that must be trimmed off constitutes a waste of 3.2 per cent.

4. In rotary cut veneer the core of the log, usually over 6 inches in diameter, can not be cut into veneer. As reported by the veneer manufacturers, the cores represented 16.5 per cent of the lumber used. Most of the lumber represented by the cores was utilized in one way or another, usually for some cheap product for which an inferior grade of lumber could have been used. In some mills, however, the core is used only as fuel for the furnace or is not utilized at all. Reports show a total waste from this source of 3.1 per cent of the lumber used for veneer.

5. Veneer from its very nature is very fragile, and unless it is carefully handled there is a heavy loss due to breakage. The output of 5 per cent of the lumber used, as reported, was broken in handling.

6. A further loss of from 4 to 5 per cent of veneer is caused by checking, warping, and staining in the process of seasoning.

Thus, from the sources enumerated above, there is a waste of about 25 per cent of the total lumber used in this industry. An additional loss of 5 per cent may be safely allowed for other wastes, such as carelessness, etc., bringing the total loss up to 30 per cent.

There is no doubt that part of this waste can be saved by more careful manufacture, while a part of the necessary waste may be utilized in various ways.

WASTE IN MANUFACTURE OF COOPERAGE.

About 1,250,000,000 board feet of lumber were used in the cooperage industry in 1907. Of this amount about 500,000,000 feet were used for tight and the rest for slack cooperage.

The following extract, taken from a Forest Service report prepared by a man who has made a special study of this industry, discusses the loss incurred in the manufacture of slack cooperage and suggests methods of saving the waste:[a]

> Waste in the manufacture of any highly specialized wood product seems to be a necessary and unavoidable evil, and the manufacturer of slack cooperage is perhaps not more wasteful than his fellow wood users. Though probably as much as 40 to 50 per cent of the round timber is unused in the manufacture of staves and hoops and about 75 per cent in the manufacture of

[a] Unpublished report on "Woods for Slack Cooperage and their Economic Utilization," by J. J. Levison, pages 14–19.

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heading, only part of this loss can be prevented. The waste is not due to one particular cause but rather to a large number of small causes, which in the aggregate amount to considerable.

The cooperage man must have green timber, and yet hundreds of logs or blocks will often be allowed to lie on the yard or in the woods until they become too dry or too checked for cooperage purposes. In Ohio a log is considered green which has been cut five months or less, or until it begins to shed its bark.

At the mill there is often great waste in cutting logs into heading lengths when they are intended to be cut into stave lengths. Heading blocks will often be cut 21 inches long when only 17½ or even 15 inch heading will be circled out of them, and the matcher, in his haste or carelessness, will also frequently cause another waste of 2 inches by the wrong choice of boards. When logs intended to be used for staves are cut in the woods into lengths in multiples of 32 inches and then found when they reach the mill to be unsuitable for staves they are divided into 21-inch lengths and used for heading. This will cause a waste of 3 inches in a log that was cut for six stave lengths, and a waste of 13 inches in a log that was cut for five stave lengths. In the latter case there will be a wasted piece which is too short for a heading block and which will go into the waste pile. To prevent this waste, there is need of intelligent supervision and knowledge on the part of the woods foreman as to the purpose for which each log is best suited. Many logs are also cut a few inches too short in the woods, and the last block must be thrown out at the mill. The logs can often be cut longer, either by going a little higher into the top or by cutting a lower stump.

Improper bolting for staves is another cause of considerable waste. In many mills, instead of being first cut into short blocks and then into bolts, the whole log is first sawed lengthwise into "cants" (sections) and then divided into the requisite short bolts. As generally practiced, this method does not give bolts of the proper slanting form. Moreover, the grain of the log does not generally run parallel to its axis for the entire length, so the bolts cut by the canting method will be more or less cross-grained and hence produce an inferior grade of staves and cause a greater waste.

The preparation of bolts by splitting instead of sawing, still practiced at a few southern mills, is also wasteful one. The fibers of a split bolt generally run parallel to its axis, while the straightness of the grain of a sawed bolt depends upon the skill of the man at the bolting saw. The bolter is apt to produce a cross-grained bolt which will give rough staves, but the waste thus caused is small compared with that which always results from the split bolt. At least the first two and the last two staves in every split bolt have to be discarded because the sides of the bolt are uneven, so that for a given volume of timber sawed bolts will produce more staves of good quality than can be obtained from split bolts.

Carelessness in stave jointing is a very common occurrence and produces much waste. A hard wood with many knots will often cause the jointer to cull hundreds of staves, the defects of which could have been cut around and the staves saved.

After the staves have been manufactured there is a very considerable amount of waste in seasoning. Correct piling is an important factor in both air and kiln drying, and close attention to it would save much stock.

The utilization of the unavoidable waste is a problem which sooner or later will confront every manufacturer of wood, and an early consideration of the subject is most advisable. Whether the loss be due to the oversight of the manufacturer or to the nature of the process, the quantity of discarded wood in slack cooperage manufacture is great, and a considerable proportion of it, such as slabs, culled blocks, and hoop planks, could be rescued from the waste pile at a profit. In many cases the slabs could be used for sawed hoops at a reasonable gain and the culled and broken hoops could be turned into head liners. There is also a possibility that the culled blocks and hoop planks could be made into dimension stock or some other salable product.

The first concern of the cooperage manufacturer should be to prevent the waste as far as possible, and this should start with the cutting of the tree in the woods where a determination as to the purpose which the log will best serve is fully as necessary as a careful working up later.

A great saving of waste can be made in many cases by bettering the methods of manufacturing and handling the stock. The lack of a combined stave, heading, and hoop mill causes much waste. In order to utilize every log and give each one its most economic place, there must be a combination of at least stave and heading manufacture. A log that will not make a good hoop will often

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make good staves, and one too poor or too small for staves will often turn out excellent heading. But the numerous mills that make only one kind of stock are compelled to throw out unsuitable logs, blocks, and planks that could have served a useful purpose in some other branch of the slack-cooperage industry. Not only should there be, as far as possible, a combination of the various branches of the industry, but as well a careful selection of the machines in the mill and careful attention to their operation and maintenance.

The utilization of the waste pile is a possibility that the local markets and the labor question must, in a large measure, determine. In some localities the waste is selected and sold to factories for the manufacture of wooden novelties, such as shoes, toys, spools, toothpicks, clothespins, and the like. Further investigation may develop the economic possibility of using other parts of the waste for distillation or for pulp. The use of spoiled finished staves as substitutes for shingles on cheap buildings is suggested. Such of the waste as can not be put to any of these uses will supply fuel, and is so used in several mills, the ashes being sold locally for fertilizer, or shipped to be mixed with southern phosphates.

From the above extract it may be seen that Mr. Levison's conclusion that from 40 to 50 per cent of the round timber is wasted in the manufacture of staves and hoops, and as high as 75 per cent in the manufacture of heading, is not exaggerated.

Although the cooperage manufacturers realize that there is a certain loss of lumber incurred in their industry, yet few realize how large this loss is. In a schedule of questions sent out to the leading cooperage men the following was included: "Comparing the volume of the logs or bolts used with the volume of the product, what per cent of material is wasted in the manufacture of staves?" The answer to this question varied from 2 per cent to 66 per cent. The next question on the schedule, "In what way, if any, is this waste utilized?" brought an almost unanimous answer, "For fuel."

Answers to another question on the schedule bring out the fact that, on an average, slack stave bolts are cut 2 inches longer than the staves are to be. Assuming an average length of stave of 24 inches, there is a loss of one-thirteenth of the bolt length, or 7.7 per cent of the total lumber cut for staves.

A heavy loss is also entailed in seasoning cooperage stock. Eighty-five per cent of the output of slack staves is air-dried and 15 per cent is kiln-dried. The loss in air-drying comes from warping, checking, and staining, and amounts to about 4 per cent, on an average. Almost all the loss in kiln-drying occurs from warping, and amounts to but 1 or 2 per cent.

Forty per cent of the slack heading produced is air-seasoned, 60 per cent is kiln-dried. The loss through warping, checking, and staining in the first case averages 5 per cent. If kiln-dried, it amounts to only about 3 per cent. This indicates a loss of from 3 to 4 per cent in seasoning slack cooperage stock.

Of tight staves 40 per cent are kiln-dried, with an average loss through checking, warping, etc., of 2 per cent, and 60 per cent are air-dried, with an average loss of 6 per cent.

Tight heading is half air-dried, half kiln-dried. The loss in the first case is 5 per cent, in the latter case it is only about 2 per cent. The average loss incurred in drying tight cooperage is therefore about 4 per cent.

The methods of reducing loss in cooperage are (1) through greater care in the various processes of manufacture; (2) better and more highly specialized machinery; and (3) a more thorough utilization of the waste.

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WASTE IN USE OF TIMBER.

By McGarvey Cline,
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INTRODUCTION.

The following discussion is based upon data compiled by the Bureau of the Census and upon reports furnished to the Forest Service by lumber dealers and manufacturers representing the larger lumber-consuming industries. A rather careful search through the lumber trade journals and library references disclosed very little information on the subject of this report. In many cases the data secured were not complete enough to be more than indicative; the discussion, therefore, is only to be regarded as an effort to present the best material available.

CONSUMPTION OF LUMBER BY DIFFERENT INDUSTRIES.

Reports received from 36 railroads, representing 37 per cent of the total railroad mileage of the United States, show that the various lines reporting used, in 1907, 417,800,000 board feet of lumber for car building and 183,600,000 board feet for bridge timbers. Assuming that this same rate of consumption applies to the total mileage (210,000 miles) the railroads of the United States in 1907 consumed 1,128,000,000 board feet for car building and 496,000,000 board feet for bridge construction. In addition to this, 1,155,000,000 board feet of sawed cross-ties were used; these various items making a total consumption, during 1907, of 2,797,000,000 board feet, 7 per cent of the total lumber cut for that year. It must be remembered that this discussion of lumber consumed by the railroads applies only to sawed lumber and does not include the enormous quantity of forest products used in the form of hewed ties, piling, and poles.

Table I contains data taken from Part I of the Census of Manufactures of 1905. At the bottom of the table the matter contained in the various columns is described. The classification of industries, shown in column A, is that given by the Bureau of the Census. The figures in column B show the cost of the raw material consumed by the different industries. Column C gives the average value of the lumber consumed in dollars per thousand feet board measure. These values are based upon the prices of lumber prevailing in 1904. Column D is secured by dividing the figures in column B by those in column C.

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TABLE I.—*Consumption of lumber by wood-using industries in 1904.*

Lumber-using industries.	Cost of material used.	Average price per 1,000 feet B. M.	Lumber consumed, millions of board feet.	Lumber consumption in per cent total lumber cut.
Furniture and cabinet work:				
Furniture	$69,861,123	$16	4,300	12.60
Coffins	9,156,299	14	655	1.92
Billiard tables	885,676	17	52	.15
Picture frames	4,825,702	16	300	.88
Refrigerators	3,086,886	14	220	.64
Sewing machines	2,266,628	16	141	.41
Show cases	2,254,787	16	141	.41
				17.01
Boxes:				
Cigar	3,366,823	18	187	.55
Packing	31,397 410	12	2,610	8.00
				8.55
Agricultural implements	18,200,000	16	1,140	3.30
Carriage and wagon manufacturing	10,338,000	20	516	1.50
				4.80
Ship building	6,700,000	12	558	1.64
Miscellaneous:				
Artificial limbs	122,942	18	68	.02
Lasts	689,103	16	43	.13
Matches	3,142,750	12	220	.76
				.91

Assuming that the building trades consume all the lumber not included in the above estimates, Table II gives the distribution of the lumber cut of 1907 among the principal wood-using industries both in board feet and in percentages of the total cut. This table also assumes that the percentage of the total lumber cut consumed by the different industries, listed in Table I, was the same in 1907 as in 1904. Undoubtedly this assumption is not entirely correct, but it is thought that the relative quantity of material used by the different industries would change only slightly during a period as short as three years.

TABLE II.—*Showing division by industries of total lumber cut, 1907.*

	Per cent of total cut.	Million board feet.
Building trades	60.0	24,150
Furniture	17.0	6,840
Boxes	8.6	3,460
Railway and transportation	7.0	2,820
Implement and vehicle	4.8	1,930
Shipbuilding	1.6	644
Miscellaneous	1.0	402

KINDS OF WASTE.

A study of the wastes associated with the industrial use of lumber may be divided into three classes:

1. Wastes in seasoning.

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2. Wastes in manufacturing, or factory wastes.
3. Wastes due to improper use.

The third class of wastes is so interwoven with general economic conditions that it is almost impossible to deduce any definite conclusions regarding them. They will, therefore, not be considered in this discussion.

BUILDING TRADES.

The building trades, especially in the great lumber-consuming regions, secure practically all their lumber through wholesalers. Table III is based upon reports received from 340 architects. Columns 1, 2, and 3, respectively, under the sections of States, represent materials specified for high-priced, medium-priced, and cheap buildings. At the bottom of each column the number of architects reporting is given. The other figures represent the number of times the different woods were reported, expressed in percentage of the total number of reports. For example, it will be seen in Table III–A that out of 425 reports on woods specified for flooring in high-grade buildings in the New England States 41.4 per cent specified oak, 24 per cent maple, and 21.9 per cent yellow pine.

In the Pacific Coast States, out of 61 reports on the same item, 40.9 per cent specified oak, 36 per cent maple, and none specified yellow pine; 17 per cent, however, specified Douglas fir. This table is interesting in that it shows which woods are most used in the various parts of the country for flooring, siding, sheathing, joists, and shingles.

TABLE III.—*Woods specified by architects.*

A. FLOORING.

Species.	New England and Middle States.			Northern and Central States.			Southern States.			Western States.			Pacific Coast States.		
	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
Oak	41.3	14.0	2.3	48.20	23.40	5.0	43.3	26.7	.....	40.0	25.0	.....	40.3	16.2	3.7
Maple	24.0	19.5	8.0	29.20	29.00	16.6	13.5	.....	.....	26.7	8.3	.....	36.1	19.5	3.7
Yellow pine	23.9	55.2	62.6	9.70	36.20	57.3	34.9	73.3	89.0	22.2	58.3	75.0	.....	2.4	.....
Birch	5.2	5.2	2.6	8.80	.....	2.6	4.3	.....	.....	.....	.....	.....	6.6	7.2	.....
Spruce	2.8	3.9	17.7	.....	4.30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Cherry	2.4	.....	.....	(a)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mahogany	.9	2.2	5.9	1.40	1.40	14.0	.....	.....	.....	.....	.....	.....	.....	.....	.....
White pine	(a)	(a)	(a)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ash	(b)	.....	.....	.....	(b)	.....	4.3	.....	.....	.....	.....	.....	.....	.....	.....
Teak	(b)	.....	.....	(a)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Walnut	(b)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Chestnut	(a)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Cypress	(a)	(a)	(a)	(a)	(a)	(a)	.....	.....	.....	.....	.....	.....	.....	.....	.....
Douglas fir	(a)	(a)	(a)	1.35	1.40	4.0	.....	.....	.....	.....	8.4	25.0	17.0	54.7	92.6
Hazel	(a)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sycamore	(a)	.....	.....	(a)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Beech	.....	(a)	.....	1.35	5.28	(a)	.....	.....	.....	.....	.....	.....	.....	.....	.....
Basswood	.....	.....	(a)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Gum	.....	.....	.....	.....	(a)	(a)	.....	.....	.....	11.1	.....	.....	.....	.....	.....
Hemlock	.....	.....	1.9	(a)	(b)	(b)	.....	.....	.....	.....	.....	.....	.....	.....	.....
Norway pine	.....	.....	(a)	.....	.....	3.0	.....	.....	.....	.....	.....	.....	.....	.....	.....
Red cedar	.....	(a)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total reports	425	426	310	222	210	150	23	15	9	18	12	8	61	42	28

a Reported only once. b Reported only twice.

Column 1—High-priced buildings.
Column 2—Medium-priced buildings.
Column 3—Low-priced buildings.

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TABLE III.—*Woods specified by architects*—Continued.

B. SIDING.

Species.	New England and Middle States.			Northern and Central States.			Southern States.			Western States.			Pacific Coast States.		
	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
White pine	49.8	31.4	27.7	35.8	28.3	22.6				40.0	11.2				
Cypress	14.4	21.6	22.6	20.2	17.2	15.7					22.2	9.2			
Spruce	13.4	19.7	20.6	4.2	5.5	6.0									
Yellow pine	4.5	9.0	13.7	3.4	6.9	13.2	66.7	66.7	70.0	40.0	22.2	53.7			5.7
Poplar	5.0	4.7	4.4	14.4	16.6	15.1	34.0	33.3	20.0						
Oak	4.0	(b)													
Cedar	4.0	3.1	2.2	2.5	3.4	(a)						9.2			
Douglas fir	1.6	2.7	2.2	8.5	7.6	5.0					11.1	9.1	11.5	20.6	31.7
Hemlock	1.7	3.5				1.9									
Red cedar	1.6	2.3	1.3	5.1	3.4	1.9							46.3	6.9	5.7
Redwood	(b)	2.0	2.2	5.9	6.9	3.2				20.0	33.3	18.8	38.4	69.0	54.3
Basswood	(a)	(b)	3.1	(a)	2.8	12.0									
Sugar pine													3.8	3.5	2.6
Beech						(a)									
Birch		(a)													
Cottonwood					1.4	1.5									
Gum									10.0						
Hazel			(a)												
Maple		(a)													
Norway pine					(a)	1.9									
Total reports	201	257	226	118	145	159	9	12	10	5	9	11	26	29	35

a Reported only once. b Reported only twice.

Column 1=High-priced buildings.
Column 2=Medium-priced buildings.
Column 3=Low-priced buildings.

C. JOISTS.

Species.	New England and Middle States.			Northern and Central States.			Southern States.			Western States.			Pacific Coast States.		
	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
Yellow pine	51.2	34.8	26.4	61.2	48.3	38.7	100.0	91.6	87.5	40.0	50.0	77.7			
Spruce	29.7	39.6	27.2	3.1	1.32	1.48									
Hemlock	12.1	22.2	43.5	4.35	14.5	38.0									
White pine	2.2	1.02	.725	8.7	12.4	8.05						11.2			
Oak	1.92			1.86	.69			8.4							
Norway pine	.96	1.02	.51	13.7	16.6	10.2									
Chestnut	.96	.34	.725												
Maple	.64	.68													
Poplar	.32	.34		1.24	.69	1.46									
Douglas fir			.725	6.84	5.5	2.19				60.0	50.0	11.1	100.0	100.0	100.0
Cypress			.51												
Gum									12.5						
Total reports	313	295	276	161	145	137	10	12	8	10	8	9	25	20	27

Column 1=High-priced buildings.
Column 2=Medium-priced buildings.
Column 3=Low-priced buildings.

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TABLE III.—*Woods specified by architects*—Continued.

D. SHEATHING.

Species.	New England and Middle States.			Northern and Central States.			Southern States.			Western States.			Pacific Coast States.		
	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
Yellow pine	35.7	32.9	33.8	45.0	45.0	37.4	80.0	68.7	70.0	71.4	80.0	80.0	.....	.....	.....
Spruce	20.7	19.8	17.5	2.8	2.3	1.6	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hemlock	16.9	23.0	39.6	11.7	21.4	39.9	.....	.....	.....	.....	.....	.....	.....	.....	.....
White pine	13.6	5.7	3.6	22.5	16.0	11.7	.....	.....	.....	14.3	.....	.....	.....	.....	.....
Cypress	5.2	8.9	3.3	3.6	3.6	3.1	.....	.....	.....	14.3	10.0	20.0	.....	.....	.....
Ash	2.5	2.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Maple	2.7	2.1	(a)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oak	2.7	(a)	(a)	.....	.....	.....	10.0	6.3	10.0	.....	.....	.....	.....	.....	.....
Basswood	(b)	3.2	2.2	.....	.....	.....	.....	6.3	.....	.....	.....	.....	.....	.....	.....
Douglas fir	(b)	(b)	(a)	4.5	2.3	1.6	.....	.....	.....	.....	10.0	.....	84.6	88.5	88.5
Mahogany	(b)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Norway pine	(b)	.....	.....	8.1	8.4	4.7	.....	.....	.....	.....	.....	.....	.....	.....	.....
Poplar	(b)	(a)	.....	1.8	(a)	.....	10.0	12.5	10.0	.....	.....	.....	.....	.....	.....
Cedar	(a)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Chestnut	(a)	(b)	(a)	.....	.....	.....	.....	6.2	.....	.....	.....	.....	.....	.....	.....
Gum	.....	.....	.....	.....	.....	.....	.....	.....	10.0	.....	.....	.....	.....	.....	.....
Redwood	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15.4	11.5	11.5
Total reports	233	277	275	111	131	128	10	16	10	7	10	10	26	26	26

a Reported only once. b Reported only twice.

Column 1—High-priced buildings.
Column 2—Medium-priced buildings.
Column 3—Low-priced buildings.

E. SHINGLES.

Species.	New England and Middle States.			Northern and Central States.			Southern States.			Western States.			Pacific Coast States.		
	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
White cedar	48.7	52.0	43.6	31.0	32.6	28.9	.....	.....	.....	12.5	.....	.....	.....	.....	.....
Cypress	24.7	27.0	25.7	15.6	20.3	21.6	55.5	42.8	33.3	12.5	25.0	37.5	.....	.....	.....
White pine	8.9	7.8	9.6	22.4	9.4	13.4	22.2	7.1	11.2	12.5	.....	.....	.....	.....	.....
Red cedar	7.7	7.8	7.5	9.1	28.2	20.4	.....	7.1	.....	50.0	62.5	50.0	61.5	56.5	50.0
Redwood	7.3	4.3	2.1	9.9	5.1	5.2	11.1	14.3	11.1	.....	.....	.....	38.5	43.5	50.0
Douglas fir	2.7	(a)	1.2	2.0	4.4	1.5	.....	.....	.....	12.5	12.5	12.5	.....	.....	.....
Spruce	(a)	1.1	5.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Yellow pine	(a)	.....	1.2	.....	.....	2.2	11.2	28.7	33.3	.....	.....	.....	.....	.....	.....
Hemlock	.....	.....	3.7	.....	.....	3.0	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oak	(a)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Poplar	.....	.....	.....	.....	.....	.8	.....	.....	11.1	.....	.....	.....	.....	.....	.....
Norway pine	.....	.....	.....	.....	.....	3.0	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total reports	247	282	241	152	138	134	9	14	9	8	8	8	39	39	42

a Reported only once.

Column 1—High-priced buildings.
Column 2—Medium-priced buildings.
Column 3—Low-priced buildings.

To ascertain the relative amount of different forms of materials consumed by the building trades, schedules were sent to wholesale lumber dealers in different sections of the country. Replies were received from most of the important markets of the country, but they were not uniformly filled out, and in many cases were incompletely answered. The replies which were sufficiently complete to be used in this report cover 780,400,000 board feet of soft woods and 34,600,000 board feet of hard woods. Table IV is based upon these schedules and shows the aggregate quantity of each species reported and what

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percentage of this quantity consisted of the various forms indicated by the column headings.

TABLE IV.—*Stock handled by wholesale lumber dealers.*

Species.	Total quantity reported.	Common boards.	Inside finish.	Siding.	Ceiling.	Flooring.	Plank and dimension.
Soft woods:	*Board feet.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Yellow pine	348,321,000	21.4	10.5	4.3	3.3	5.2	55.3
Douglas fir	138,434,000	10.6	4.8	4.1	4.1	6.4	70.0
Redwood	107,458,000	6.3	22.6	20.1	4.8	.9	45.3
Northern pine	47,922,000	81.0	10.5	.5			8.0
Spruce	12,000,000	100.0					
Western pine	6,277,000	40.5	18.8	4.6	.5	1.5	34.1
Hemlock	785,000	42.0					58.0
Cedar	337,000			100.0			
Cypress	270,000	92.6	6.3				1.1
Unclassified	117,650,000	18.9	57.0	1.3	.4	1.5	20.9
Hard woods:							
Oak	5,955,000	24.2	.3			.3	75.2
Poplar	3,655,000	45.7	.4	28.1	.8		25.0
Birch	2,589,000	96.6	.4			3.0	
Maple	243,000	28.8				71.2	
Other hard woods	3,565,000	100.0					

Table V is compiled from the same set of schedules. The column headed "Distribution by form" shows that of the soft woods handled 44.7 per cent was finish and siding; 12.6 per cent common boards; 28.6 per cent plank; 14.1 per cent rough dimension. The horizontal column marked "Distribution by industry" shows that 82 per cent of the total soft woods was consumed by the building trades; 2.5 per cent by the furniture factories; 15.2 per cent by the box factories; and 0.3 per cent by the vehicle and implement industry. This table also shows what percentage of the total quantity of each form considered is consumed by the building trades, furniture, box, and vehicle and implement factories. For example, all of the finish and siding reported was consumed by the building trades, while of the soft-wood boards reported 39 per cent was used for building, 5.2 per cent for furniture, 54.8 per cent for boxes, and 1 per cent for vehicles and implements. The lower part of the table indicates in a similar way the distribution of the hard woods handled. From these data on the quantity and form of the material consumed by the building trades, it seems that 50 per cent consists of finish, siding, and flooring; 5 per cent of sheathing and common boards; and 45 per cent of joists, scantling, and dimension.

TABLE V.—*Distribution of material handled by wholesale lumber dealers.*

Form of material.	Distributed by form.	Building trades.	Furniture.	Box.	Vehicle and implement.
Soft woods:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Finish and siding	44.7	100.0			
Boards	12.6	39.0	5.2	54.8	1.0
Plank	28.6	100.0			
Dimension	14.1	83.0	8.3	8.2	.5
Distributed by industry	100.0	82.0	2.5	15.2	.3
Hard woods:					
Finish and siding	12.0	100.0			
Boards	78.6	50.6	44.4	3.0	2.0
Plank	9.4	21.2	62.3		16.5
Distributed by industry	100.0	53.8	40.8	2.4	3.0
All woods		82.0	2.5	15.2	.3

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WASTES.

In the building trades there is always a considerable percentage of waste lumber; therefore, after computing the exact quantities indicated in the plans for a building, contractors add the following percentages to the different items of lumber to cover waste. These figures were secured from various handbooks and from reports received from a few building contractors:

	Per cent.
Joists and scantling (very frequently no waste is allowed in these items)	2
Sheathing:	
Laid horizontally	17
Laid diagonally	20
Siding:	
Drop	20
Laid 4" to the weather	50
Flooring and ceiling, square edge:	
6-inch flooring	11
4-inch flooring	20
Flooring and ceiling, matched:	
6-inch flooring	17
4-inch flooring	20
2¼-inch flooring	33
1⅜-inch flooring	40
Shingles:	
Plain roof	8
Gable roof	12

By further classifying the above figures it is found that in the use of finish, siding, and flooring the average waste is about 20 per cent; for sheathing it is 18 per cent, and for joists and dimension 2 per cent. These weighted according to the relative amounts of the various classes consumed give an average waste of 12 per cent in general building operations. It is estimated that from the mill to the consumer there is also 3 per cent waste in seasoning due to checks, stains, etc. The total waste, therefore, in building materials is approximately 15 per cent, which annually amounts to 3,600,000,000 board feet.

FURNITURE.

The lumber consumed by the furniture industry is with few exceptions in the form of board, plank, small dimension, and veneer. Table V indicates that 40.8 per cent of the hard woods handled by wholesale lumber dealers and 2.5 per cent of the soft woods are consumed by this industry, but the larger part of the material used is purchased direct from the mill operators or is manufactured at mills operated by large furniture concerns.

Practically all of the commercial hard woods, with the possible exception of hickory, furnish raw material for this industry. From card reports received from 2,482 furniture establishments in the United States it seems that the woods used, with respect to quantity, range themselves as follows:

	Per cent.		Per cent.
Oak	45	Elm	5
Maple	11	Gum	5
Birch	7	Chestnut	4
Yellow poplar	6	Basswood	4
Beech	5	Ash	3

All others, including walnut, mahogany, pine, hemlock, Douglas fir, etc., 5 per cent.

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WASTES.

Reports from 61 manufacturers of different classes of furniture show an average loss of 5 per cent in seasoning furniture woods. Table VI is based on the same reports. It shows the average waste in manufacturing various classes from different grades of lumber. The estimates on waste associated with the use of different grades for any particular class of furniture varied considerably. The table, however, shows the range in the estimates furnished by giving the average of the highest one-tenth and the average of the lowest one-tenth of the total number of reports received on each item.

TABLE VI.—*Wastes in the furniture industry.*

[Based on reports received from 61 manufacturers of different classes of furniture.]

Classes.	Grades used.				
	Uppers, firsts and seconds.	No. 1 common.	No. 2 common.	Mill run.	General average.
Tables:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Average	22	34	39	32	
Average high	29	46	47	36	32
Average low	13	24	33	28	
Cabinets, desks, china closets, bookcases:					
Average	17	32			
Average high	27	55			25
Average low	10	15			
Chairs:					
Average	22	26			
Average high	25	33			24
Average low	15	20			
Bedroom sets:					
Average	25	31	36		
Average high	25	34	43		30
Average low	25	28	29		

In figuring the percentage of waste, most manufacturers measure up the amount of lumber required, according to the design of the piece of furniture under question, then add to this amount a certain percentage, which experience has shown necessary, depending upon the quality of the lumber to be used. In some cases the species is also considered, since some species contain more knots, checks, etc., than others. The table shows the range in wastes reported.

The grades most commonly used are firsts, seconds, No. 1 common, and No. 2 common.

The deduction from these figures is that 25 per cent is a conservative estimate for factory waste in this industry, or 20 per cent, expressed in terms of material purchased. Both factory and seasoning wastes combined amount approximately to 25 per cent, which represents an annual waste of 1,710 million board feet.

BOX FACTORIES.

Table V indicates that 15.2 per cent of the soft woods and 2.4 per cent of the hard woods handled by the wholesalers are consumed by the box factories. This industry, however, secures by far the largest part of its supply direct from the mill, very often the box factory being run in conjunction with the sawmill or a large planing mill.

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Practically all low-priced woods are used. In the New England region white pine is the leading material, although spruce and hemlock, as well as poplar, basswood, chestnut, and other woods are also used. In the South Atlantic States, North Carolina pine is the prevailing material; in the Lake States white pine leads; in the Southern States a great variety of woods are used, cottonwood, gum, and yellow pine being the most important; in the Pacific coast States the western white pine, spruces, and firs predominate.

WASTES.

The loss due to seasoning box material is conservatively estimated at about 3 per cent, and the factory waste, which is generally expressed as a percentage of the actual volume of the material entering the finished box, varies from 10 to 20 per cent, 15 per cent being a conservative average. The combined factory and seasoning wastes would therefore amount to approximately 20 per cent, which represents an annual waste in board feet of 692,000,000.

RAILWAY AND TRANSPORTATION LINES.

The species furnishing the bulk of material used by the railroad and transportation lines are yellow pine, Douglas fir, and oak for car and bridge material; and for ties, in addition to the above, cedar, chestnut, western pine, tamarack, redwood, cypress, and several others in much smaller quantities.

WASTES.

Out of 35 railroads reporting on waste of material in car building, 4 report no waste, 6 report 5 per cent, 9 report 10 per cent, 12 report 15 per cent, and 4 report 20 per cent; this gives a general average of approximately 11 per cent. Out of 33 railroads reporting on waste in bridge building, 8 report no waste, 12 report 5 per cent, 8 report 10 per cent, and 4 between 10 and 15 per cent, with an average of approximately 6 per cent. Out of 30 roads reporting, 15 report no loss due to seasoning, 10 report between 1 and 5 per cent, 2 between 5 and 10 per cent, and 3 between 10 and 15 per cent, with an average of approximately 3 per cent. These averages weighted according to annual consumption give an average total waste of 10 per cent in bridge and car material, which represents an annual loss of 282,000,000 board feet.

VEHICLE AND AGRICULTURAL IMPLEMENTS.

These industries, as indicated in Table V, secure some material through wholesalers, but by far the larger quantity of lumber consumed is purchased in the form of plank, flitches, or small dimension, direct from the sawmills. The species most commonly used are as follows:

Box boards	Yellow poplar, cottonwood, red gum, tupelo.	Reaches	Oak.
		Standards	Oak, rock elm, hickory.
Box cleats	Yellow poplar, cottonwood, rock elm.	Hounds	Oak, rock elm.
		Spokes	Oak.
Box beds	Longleaf pine, birch, oak.	Rims and fellies	Oak, Osage orange (southern trade).
Bed cleats	Oak, rock elm.		
Axles	Hickory, maple.	Hubs	White, red, and willow oak, black and yellow birch.
Bolsters	Oak, hickory.		
Sand boards	Oak, hickory.	Doubletrees	Hickory, rock elm, oak.
Poles	Oak.	Singletrees	Hickory, rock elm.
Brake bars	Oak, rock elm.	Neck yokes	Hickory, rock elm.

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SEASONING WASTES.

The hard woods used in vehicle manufacture are first air-dried from two to four years and then kiln-dried; accordingly, the loss due to seasoning such stock may be divided into losses due to air-drying and losses due to kiln-drying. The following table gives the total losses due to seasoning rough dimension, plank, and boards of the woods most generally used:

TABLE VII.—*Percentage lost in seasoning.*

Species.	Rough dimension.	Plank.	Boards.
Hickory	11	11	12
Oak	10	10	12
Poplar	12	11	11
Ash	9	11	12
Maple	6	9	6
Pine	10	7	6
Elm	7	8	3

These figures indicate an average waste of 10 per cent in seasoning vehicle and implement woods.

Table VIII is based on 159 reports received from manufacturers of carriages, wagons, wheels, rims, poles, shafts, and gears. The table shows the relative amount of waste in manufacturing the finished articles from different forms of material. For example, the waste in the manufacture of axles from dimension based upon 10 reports averages 16 per cent and the estimates furnished range from a minimum of 6 per cent to a maximum of 26 per cent. It is, therefore, evident that not much significance can be attached to the figures showing average waste. From the data it contains it is estimated that there is an average factory waste of 15 per cent in manufacturing the various parts of vehicles from raw material in the form of dimension, billets, plank, or boards. The total waste, therefore, in the vehicle and implement industries amounts to approximately 25 per cent, representing an annual loss of 482,000,000 board feet.

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TABLE VIII.—*Wastes, vehicles and implements.*

[Based on reports received from 159 manufacturers.]

Article.	Form of material.															
	Dimension.				Billets and blocks.				Plank and flitches.				Boards.			
	Number of reports.	Average percentage of waste in manufacturing from rough stock.	Average high percentages.	Average low percentages.	Number of reports.	Average percentage of waste in manufacturing from rough stock.	Average high percentages.	Average low percentages.	Number of reports.	Average percentage of waste in manufacturing from rough stock.	Average high percentages.	Average low percentages.	Number of reports.	Average percentage of waste in manufacturing from rough stock.	Average high percentages.	Average low percentages.
Axles	10	16	26	6	....	....	....	....	....	....	....	....	....	....	....	....
Bent work	2	10	10	10	....	....	....	....	11	20	28	12	....	....	....	....
Bolsters	8	12	22	4	....	....	....	....	....	....	....	....	....	....	....	....
Carriage bodies	....	....	....	....	....	....	....	....	....	....	....	....	40	17	35	6
Gears	20	13	22	8	....	....	....	....	38	19	44	6	....	....	....	....
Hubs	....	....	....	....	26	18	38	5	....	....	....	....	....	....	....	....
Poles	14	11	18	4	....	....	....	....	9	29	45	13	....	....	....	....
Rims	....	....	....	....	....	....	....	....	39	23	48	10	....	....	....	....
Seats	....	....	....	....	....	....	....	....	....	....	....	....	9	20	25	13
Shafts	5	12	18	8	....	....	....	....	9	25	37	13	....	....	....	....
Shaft crossbars	....	....	....	....	....	....	....	....	3	28	35	25	....	....	....	....
Spokes	....	....	....	....	23	27	54	8	....	....	....	....	....	....	....	....
Single and double trees	1	8	8	8	....	....	....	....	8	27	35	19	....	....	....	....
Wagon bodies	....	....	....	....	....	....	....	....	66	17	42	6	26	18	31	9
General average (estimated)	....	12	....	....	....	22	....	....	....	20	....	....	....	18	....	....

SHIPBUILDING AND MISCELLANEOUS.

No figures are available showing the wastes associated with shipbuilding and other miscellaneous wood-using industries. In some of these industries—for example, in the manufacture of spools, shuttles, toys, etc.—the percentage of waste is very high, but since the relative quantity of material consumed by them is so small, they have little economic significance. It is safe, however, to assume that at least 15 per cent is wasted, representing an annual loss of approximately 157,000,000 board feet.

A general summary of the foregoing discussion is shown in Table IX:

TABLE IX.

Industry.	Estimated consumption, 1907, millions board feet.	Average percentage of waste.	Annual waste, millions board feet.
Building trades	24,150	15	3,600
Furniture	6,840	25	1,710
Boxes	3,460	20	692
Railway and transportation companies	2,820	10	282
Vehicle and implement	1,930	25	482
Shipbuilding and miscellaneous	1,046	15	157
Total or average	40,246	17	6,923

This total waste of 6,803,000,000 board feet represents 17 per cent of the lumber cut of 1907. It is made up mostly of sawdust, shav-

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ings, and small blocks, and nearly all of it is burned under factory boilers or as kindling wood; so in the true sense of the word it is not actually wasted, but merely serves a lower purpose than that for which the lumber was manufactured.

SUBSTITUTES.

The wastes due to improper use of lumber are undoubtedly great, but they are difficult to define or to study statistically. A brief review, however, of materials being substituted for lumber may prove helpful in suggesting what these wastes are and to what extent their elimination will diminish the annual consumption of lumber.

BUILDING TRADES.

The enormous supply of building stones and other raw material used in the manufacture of brick, concrete, etc., undoubtedly insures a very rapid decrease in the use of lumber as a building material. This tendency is already very marked in most of the large cities, and when it is remembered that the building trades consume 60 per cent of the entire lumber production, it seems that they offer the best field for decreasing the present enormous consumption.

RAILWAY AND TRANSPORTATION LINES.

Railroads are already using steel to a large extent in car construction and its use for this purpose is constantly increasing. It is almost universally used in car underframes and, to an increasing extent, for the bodies of both freight and passenger coaches. The Pennsylvania Railroad Company estimates that the total weight of wood in one of its modern passenger cars is not over 400 pounds, while many hoppers and other types of freight cars are built entirely of steel. On practically all of the well-established roads steel and concrete are being used for bridges in all new work except where such work is of a temporary character, and it is the general policy to replace wooden bridges with concrete and steel as rapidly as funds will permit.

FURNITURE INDUSTRY.

In the furniture industry brass and iron beds are to a large extent, used in the place of wooden ones. One manufacturer estimates that approximately 50 per cent of the beds now manufactured are of metal. Some restaurant tables are made with iron or wire supports, and pressed steel desks finished in wood, as well as steel typewriter chairs, and steel file cases are coming into use for office purposes.

PACKING BOXES.

The use of veneer and pulp board promises to diminish the amount of lumber required by the box industry and the tendency to adopt standard sizes is doing a great deal to increase the life of the packing box by making it available for reshipments. In general, however, wood in some form seems to be best adapted to the requirements of this industry.

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VEHICLES AND IMPLEMENTS.

On account of the increasing scarcity and consequent high price of woods, such as hickory and oak, commonly used by vehicle makers, many substitutes have been tried. The substitution of metal for wood in vehicle construction is practiced to a limited but slowly increasing extent. Steel for axles, rims, hubs, and wire for spokes and sheet iron for body paneling are used. Metal paneling, however, has the drawback of bending easily. Endeavors to make such substitutions are very often unfavorably received by wagon users on account of the rigid and unyielding character of steel construction.

SHIPBUILDING AND MISCELLANEOUS INDUSTRIES.

Steel is rapidly becoming the exclusive material for constructing the hulls of all kinds of water craft, and such materials as pulp fiber, papier-maché, and various metals are rapidly supplanting lumber for such articles as buckets, toys, artificial limbs, etc.

It thus seems quite possible for the country to adapt itself to a per capita lumber consumption not more than one-half as great as at present.

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TAXATION OF TIMBER LANDS.

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Chapter I.

INTRODUCTORY.

I. GENERAL PRINCIPLES OF TAXATION.

It is safe to say that nowhere in the whole domain of applied economics do we find such general confusion and such wide discrepancy between principle and practice as in the field of taxation. As an introduction to the study of timber-land taxation, it will be wise to lay down at the outset certain principles of taxation which are fundamental and generally accepted.

Every government requires some revenue in order to carry on its necessary functions. In modern States this revenue comes in the main from taxation. This is particularly true of the United States, where other forms of revenue are relatively insignificant.

Taxation necessarily involves sacrifice on the part of the taxpayer. This sacrifice is justified on the ground of the benefit to the public resulting from the operation of government functions. This principle also is the only correct guide to the proper amount of taxation. So long as the benefit to the public as a whole through the use of wealth by the State is greater than if this wealth were used by the individuals from whom it is taken, the imposition of taxes is justified. Otherwise, taxation is excessive.

The purpose of taxation is to obtain revenue. Incidentally, however, the taxing power has almost universally been used to accomplish certain other desired ends. Well-known illustrations are our liquor-license system, our protective tariff, the federal tax on the notes of state banks, etc. Where such a programme unquestionably increases the public welfare, there would seem to be no objection on the ground of principle. In the same way, taxation at a reduced rate or complete exemption may sometimes be granted in cases where an undoubted benefit to the community will result. Obviously such uses of the taxing power are peculiarly open to abuse and should be strictly limited.

In apportioning the burden of taxation among the citizens, it is a truism to say that taxation ought to be just. It is by no means so easy to define clearly what we mean by justice, or to discover what particular method of apportionment will best secure our ideal. The simplest method is equal apportionment; that is, an equal burden on

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every citizen. This crude plan has prevailed in primitive times, and it is conceivable that under certain conditions it might work fairly well. Just as soon, however, as the most primitive conditions are past, the unequal burdens caused by such apportionment become intolerable.

A second plan of apportionment is based upon the benefit theory. This plan attempts to collect from each citizen a payment in proportion to the particular benefit received by him on account of government services. But the benefits of government are mainly general. How then shall we measure the benefit to any particular citizen? Those who advocate this theory have generally gone on the assumption that the main function of government is to give protection to life and property. It is therefore assumed that, since the benefit of protection to life may be considered equal and the benefits to property proportional to the amount of the property, a correct apportionment of taxation would require an equal poll tax, with the remaining burden of taxation apportioned among the citizens according to the amount of property owned by each. This is in brief the idea of the benefit theory, a theory which is held in a vague sort of way by many people, and has been rather tenaciously adhered to by the legal profession in the United States.

The benefit theory is based on a number of erroneous premises. In the first place the function of government is not wholly the protection of life and property. Very many functions are performed by every modern State. Examples in the United States are too numerous and self-evident to require mention. There is therefore no ground for the assumption that the benefits derived from government are in proportion to property. As a matter of fact, the persons who are most dependent on governmental services are probably the poor and weak. The rich man is able to defend himself and to protect his property by private servants, watchmen, insurance, etc. In brief, the benefit theory would be unjust and impossible to apply. Among economists and students of public finance it has little standing to-day.

The third theory of apportionment is the so-called contributory theory or apportionment according to ability. The proposition here is to apportion the burden of taxation among the citizens according to each one's ability to pay. It is recognized that the benefits derived from government are general rather than particular, and it is maintained that the necessary expenses should be covered by contributions from all the citizens toward a common end in which all are interested. An analogy commonly referred to is the method of paying the expenses of a church or social club. Put in negative terms, the theory of ability means an apportionment which would result in equal sacrifice. The ability theory is undoubtedly the correct theory of apportionment, and the one that is coming to be generally accepted in theory and practice.

The question still remains as to what is the measure of ability or sacrifice. Ability and sacrifice are psychological conceptions, but the tax administrator must have some definite, tangible basis of apportionment. It is generally agreed that ability is to be measured in some way by the possession of wealth. Wealth exists in two forms: Either as capital, that is, an existing fund of wealth at a particular time; or as income, that is, a flow of wealth or of the services of

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wealth during a certain interval of time. Tax systems in general may be separated from each other as they apportion the burden, either according to capital or according to income. European countries in general apportion taxes according to income, whereas in the United States the general basis is the possession of capital or property.

II. THE GENERAL PROPERTY TAX IN THE UNITED STATES.

The basis of American state and local taxation is the general property tax. The theory of the general property tax contains two leading propositions: First, that property is a fair index of tax-paying ability, and second, that this index is capable of being estimated. Neither of these premises is correct. The general property tax is one of the oldest forms of taxation. It has always been the chief reliance of the American States and towns. Under the conditions prevailing in the colonial period the theory on which the tax is based was not so far from the facts, and the tax worked fairly well. The colonists were engaged mainly in agricultural pursuits, with some simple manufacturing industries and commercial enterprises. The bulk of the wealth consisted in lands, buildings, and agricultural stock and implements. Such property is easily located and its value capable of fairly accurate determination. Moreover, the relative economic position of different individuals bears a fairly close relation to their possessions. Under such conditions, the general property tax works well; assessment is fairly simple, evasion is difficult, and substantial justice is likely to be secured.

At present conditions are entirely changed. The bulk of wealth is no longer in real estate and visible personalty. To-day a large part of our property consists in stocks and bonds and other intangible evidences of wealth. Under a general property tax every individual is assumed to be assessed according to his total possessions, tangible and intangible. As a matter of fact, intangible personalty very largely escapes. In other words, the general property tax is unsuited to modern conditions. We need not describe the well-known result. Every one is familiar with the practical administration of the general property tax, and the ease with which taxes are evaded is notorious. The tax runs counter to two of the strongest motives to human action, the love of gain and the dislike of publicity. Since evasion is so easy and the motives to it so strong, it is no wonder that the administration of the general property tax has become a farce.

It is often stated that the failure of the general property tax is due entirely to administrative defects; that the tax is correct in theory and would work well if properly administered. This is not true. A general property tax is wrong in principle, and would lead to injustice and inequality even were it possible to administer it perfectly. In other words, the first premise of the general property tax is also false. Property is not a fair index of ability to pay taxes. An illustration of this will appear in the chapter on "The real economic problem of forest taxation."[a]

[a] See Chapter V, p. 611.

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In conclusion, the general property tax is a failure, historically, theoretically, and practically. Gradually the public is coming to a realization of this fact. Already many of the States have abandoned it in particular cases where its failure has become intolerable, as in the case of railroads, banks, and other corporations. We have practically, though not admittedly, given up the attempt to tax intangible personalty. A growing demand is in evidence for the giving up of the State's share in the general property tax, leaving it solely to the towns and counties. In these and other ways the movement away from the general property tax is unmistakable. In its adherence to this discredited tax the United States stands almost alone to-day. Other countries generally abandoned it long ago. Income, not property, should be the basis of any correct tax system.

CHAPTER II.

FOREST TAXATION IN THE UNITED STATES: THE LAWS.

Timber lands are taxed to-day under the general property tax in every State and continental Territory of the United States, generally in exactly the same manner as other kinds of wealth. In only twelve States [a] is any special consideration given to timber lands in the tax laws. Four other States [b] make provision for bounties for timber planting and cultivation, though these bounties have no connection with the taxation of the land or trees. Two States,[c] included, however, in the first group mentioned above, attempt to encourage the planting and cultivation of trees by offering prizes, without any reference to taxation. In all of the other thirty States and in the two Territories timber lands receive no special consideration.[d]

I. TAX EXEMPTIONS AND REBATES, AND BOUNTIES DEDUCTED FROM TAXES.

The twelve States whose tax laws make special reference to timber lands attempt to encourage the planting and cultivation of trees or the general practice of forestry by certain concessions in taxation. These concessions take the form of entire or partial exemptions from taxation, of rebates of part of the taxes, or of bounties to be deducted from the taxes.[e] The method usually employed is that of exemption. The plan of a rebate is used by New Hampshire; North Dakota uses bounties, while Wisconsin uses both exemptions and bounties. These exemptions, rebates, or bounties are granted to owners of timber lands in consideration of the planting, cultivating, growing, or protecting of trees, usually in accordance with regulations specified in the statutes, or under the direction of some state officer or board. In eight of the States the law applies only to plantations, and in five

[a] Alabama, Connecticut, Iowa, Maine, Massachussetts, Nebraska, New Hampshire, North Dakota, Rhode Island, Vermont, Washington, and Wisconsin.
[b] Illinois, Kansas, Minnesota, aid Wyoming.
[c] Massachusetts and Vermont.
[d] For a list of these States and Territories, see appendix to Chapter II, p. 587.
[e] An abstract of the statutes in each of these States will be found in the appendix to Chapter II, p. 587.

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States the land must not be wooded at the time of planting or growing the trees. In one State—Connecticut—the exemption applies only to land "not theretofore woodland."

The commonest form of tax concession consists of a complete exemption from taxes on the land and trees for a definite period of time, ranging from five to thirty years. The exemption begins either immediately after the land has been planted or set aside for the growth of trees, or after a certain period, measured either in years or in the growth of the trees.

In other States the concession is by means of a rebate of part of the taxes for a certain number of years (New Hampshire)[a] or by means of a bounty of so many dollars per acre to be deducted annually from the taxes on the land. (North Dakota and Wisconsin.)

In other States the exemption applies to the value of the trees only. (Nebraska and Washington.)

Iowa grants partial exemption to forest and fruit tree reservations by an arbitrary assessment of the land at $1 per acre.[b] Iowa also exempts from assessment the value of all planted trees.

II. BOUNTIES WITHOUT REFERENCE TO TAXATION.

In four States the attempted encouragement to forest planting and cultivation is by means of bounties having no connection with taxation. Strictly speaking, these laws do not belong in a study of taxation. However, since their general purpose is the same as the tax laws described above, and since they have some other points of resemblance to those laws, it has seemed worth while to mention them here for the sake of completeness. In only one of these cases (Minnesota) is a bounty actually offered by the State. The other three States merely give permission to the county commissioners to offer limited bounties.[c]

III. PRIZES.

For the sake of completeness we also mention the two States which provide by law for the offering of annual prizes to encourage the planting and cultivation of trees. The competitions are administered and the premiums granted through associations devoted to agriculture, etc., in the State, and funds are appropriated annually by the State for this purpose. In Vermont the law applies only to maple-sugar products.[c]

IV. CRITICISM.

None of these schemes of exemptions, rebates, bounties, and prizes has touched the real problem of forest taxation. Obviously, laws giving occasional small prizes for the best examples of tree plantations, hedge fences, etc., can have no far-reaching effects on the burdens of taxation. The same is true of the bounty laws of Illinois, Kansas, and Wyoming, which merely permit the several counties to grant small bounties for a few years. The Minnesota bounty law

[a] Pennsylvania's rebate laws have recently been declared unconstitutional.

[b] Indiana formerly had a similar law, but it has been declared unconstitutional.

[c] An abstract of these laws will be found in the appendix to Chapter II, p. 587.

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is the only one that has produced any results. Up to 1906, $440,000 had been spent by the State for this purpose, as a result of which it is claimed that some 50,000 acres have been forested.[a] If this result has indeed been accomplished it has been at a tremendous cost. Evidently we will not find a solution to the problem here.

Something more might perhaps be expected of those laws which really give some abatement of the burden of taxation by means of exemptions, rebates, and bounties. Yet here also we find that practically no results of importance have been produced. Massachusetts has had an exemption law in force ever since 1878. A legislative committee in 1906 reported that this law "has been a failure, as practically no planting has been done under it."[b] One of the members of this committee reports that he could find only 16 acres in the State that had been affected by the law since 1878.[c] With regard to the rebate law of New Hampshire, the state forestry commission reports that "This abatement provision, although 3 years old, is not widely known among landowners, and has so far been inoperative."[d] In Connecticut, the exemption law has been similarly ineffective. Similar reports come from the other States where these schemes have been in operation long enough to have produced any results. The conclusion that these laws have produced no important results is confirmed by the testimony of all who have investigated the subject.[e]

This lack of results may be explained in part by certain very important defects in these laws. In the first place, the common restriction of the tax abatement to plantations, and the further restriction in many cases to land other than woodland, in large measure destroy the usefulness of the laws at the very beginning. The real problem is in connection with, not the planting of new forests on agricultural or other land, but the protection and preservation of our present forests.

Moreover, the regulations regarding planting, thinning, etc., are not drawn in accordance with scientific forestry principles. Often the number of trees required per acre is too large. When the planting is restricted to certain specified kinds of trees, the list is not always well chosen, valuable species being often omitted. The proper thinning of the growing forest and the most profitable use of the forest are often interfered with by the requirements of the statutes.

Again, the burden of the tax reduction is not provided for or not properly placed. The justification of the concession to the timber owner lies in the advantage to the State in general. Yet the particular locality in which the land is located is called upon to bear the whole or the principal part of the burden of a diminished revenue. What the timber owner gains must be made up by heavier taxes on other local property. This point was evidently not considered at all in framing these laws.

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[a] Report of the Massachusetts legislative committee of 1905 to consider the laws relative to the taxation of forest lands, p. 10.

[b] Report of the Massachusetts legislative committee of 1905 to consider the laws relative to the taxation of forest lands, p. 17.

[c] Akerman. Southern Woodlands. June, 1908, p. 39.

[d] New Hampshire Forestry Commission Report, 1905–6, p. 204.

[e] Cf. Pennsylvania Department of Forestry Report, 1905–6, pp. 15–19; the Massachusetts Report referred to above; etc.

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Certain local assessors have taken this matter into their own hands, and have adopted the custom of adding enough to the assessment of some other property of the timber owner to make up for the reduced taxes on his timber lands. In this way they protect the local revenue, and also defeat the whole purpose of the law.[a]

The actual financial consideration in these laws is really not very great. Generally the exemption is limited to a rather short period of time, after which the land and trees are again subject to the general property tax. Moreover, the abatement comes in the years when the trees are small and when the taxes would not be very heavy anyway. The remission of taxes resulting from these laws is small when compared with the expense of planting trees and holding them to maturity.

In short, these laws are based on no sound principles either of forestry or of finance.

It is not to be inferred that the failure of these laws to produce important results is wholly due to the defects just described. It is very doubtful whether any law of this character, no matter how scientifically drawn and administered, short of a complete exemption of growing timber, can have any great influence on forests and forestry.

The effects of all these laws on the actual burden of timber land taxation may be regarded as negligible. We accordingly return to the statement with which this chapter started, that timber lands are taxed in the United States, with few and unimportant exceptions, in exactly the same manner as other wealth subject to the general property tax.

APPENDIX.

LAWS RELATING TO FOREST TAXATION IN THE UNITED STATES.

I. GENERAL SUMMARY.

Special consideration is given to timber lands in the tax laws of 12 States, as follows: Alabama, Connecticut, Iowa, Maine, Massachusetts, Nebraska, New Hampshire, North Dakota, Rhode Island, Vermont, Washington, and Wisconsin.

The States which provide for bounties, without reference to taxation, are four in number, as follows: Illinois, Kansas, Minnesota, and Wyoming.

The States which provide for prizes, without reference to taxation, are two in number, as follows: Massachusetts and Vermont.

No special consideration is given to timber lands in 30 States and 2 Territories, as follows: Arkansas, California, Colorado, Delaware, Florida, Georgia, Idaho, Indiana, Kentucky, Louisiana, Maryland, Michigan, Mississippi, Missouri, Montana, Nevada, New Jersey, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, West Virginia, Arizona, and New Mexico.

This appendix presents an abstract of all state laws which offer inducements to the planting and cultivation of trees by means of tax exemptions or reductions or by other financial considerations. They are arranged according to their subject matter in three groups: (1) Those laws which grant exemptions or rebates from taxation, or bounties to be deducted from the taxes; (2) those laws which grant bounties without reference to taxation; (3) those laws which provide for prizes for tree planting and cultivation, without reference to taxation. Strictly speaking, only those laws in the first group belong to the discussion of taxation. However, the other laws have the same general purpose, and occasionally some other points of resemblance to those in the first group, and it has seemed worth while to include them for the sake of completeness.

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[a] Elliott. Forestry and Irrigation, April, 1906, p. 178.

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The following abstract covers the main features of the statutes, but omits such details as the number of trees required per acre, regulations as to thinning, etc., which are generally provided for in the laws. The abstract is intended to cover all laws in the States and Territories of the continental United States in effect in October, 1908, but it is possible that some enactments of 1908 may have been omitted. Laws clearly held unconstitutional have been omitted.

II. TAX EXEMPTIONS, REBATES, AND BOUNTIES DEDUCTED FROM TAXES.

1. Alabama permits the owner of land which has been denuded of trees, or the assessed value of which does not exceed $5 per acre, to make a contract with the commission of forestry agreeing to plant or grow and maintain timber trees on such land for ten years, under the direction of the commission, in return for which the land is exempt from taxation for a period of ten years. (Laws of 1907, Sp. Sess., No. 90, H. 67.)

2. The Connecticut law applies to any land, not exceeding in value $25 per acre, and not previously woodland, which the owner plants to certain specified kinds of timber trees. After the trees have grown to the average height of 6 feet, the owner may obtain exemption from taxation for a period of twenty years. (General Statutes, Revision of 1902, sec. 2320.)

3. The Maine law applies to "cleared land or lands from which the primitive forest has been removed," which the owner plants or sets apart for the growth of forest trees. After the trees have been properly maintained for three years, the owner may obtain exemption from taxation for twenty years. (Laws of 1907, ch. 169.)

4. The Massachusetts law applies to plantations of certain specified kinds of timber trees, upon land which at the time of planting was not "woodland or sprout land, or land containing more than 600 standing trees to the acre," and not worth more than $10 per acre. After the trees have grown in height 2 feet on the average, the owner is entitled to exemption from taxation for ten years. (Laws of 1908, ch. 120.)

5. The Rhode Island law applies to plantations of certain specified kinds of timber trees upon land worth not more than $25 per acre. Exemption from taxation is granted for a period of fifteen years from the time of planting, provided the land is planted and managed under a forest-working plan approved by the state commissioner of forestry. Not more than 300 acres owned by a single person or corporation may be thus exempted from taxation. (Laws of 1908, ch. 1581.)

6. The Vermont law allows to uncultivated lands, planted to timber or forest trees and cared for under the direction of the forestry commissioner, exemption from taxation for ten years beginning April 1 of the second year after the planting. (Public Statutes, 1906, sec. 368–370; 496, Sub. XIV.)

7. The Wisconsin law applies to lands not within 2 miles of any incorporated city or village except upon written approval of the state forester, and not worth more than $10 per acre. If the owner of such lands sets apart any portion, not exceeding 40 acres, for forest culture and plants it with timber or forest trees, and properly maintains the trees, he is entitled to exemption from taxation for a period of thirty years from the time of planting. (Laws of 1907, ch. 592.) Wisconsin also provides that when tree belts of certain specified character are planted and properly maintained, the land on which they are planted shall be exempt from taxation until the trees reach the height of 12 feet, after which the owner is entitled to an annual bounty of $2 per acre, which bounty is deducted from the taxes assessed on the land. (Wisconsin Statutes of 1898, sec. 1469–1471.)

8. Iowa has an exemption law somewhat different from the others. The Iowa statute provides for the setting apart of so-called forest or fruit-tree reservations in private ownership, with certain restrictions as to area of the reservation, and number, species, and care of the trees. Such reservations are assessed for taxation at $1 per acre for a period of eight years from the time of planting. Moreover, in all cases where trees are planted, the assessed value of the land is not to be increased on account of the value of such trees. (Code of Iowa, Supp. of 1907, sec. 1400c–1400p.)

9. Nebraska has a statute providing that "The increased value of lands, by reason of live fences and forest trees grown and cultivated thereon shall not be taken into account in the assessment thereof." This law carries out a provision of the state constitution expressly permitting such legislation. (Compiled Statutes of 1881 with amendments to 1907, sec. 4934.)

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10. Washington exempts from taxation "all fruit trees, except nursery stock, and forest trees artificially grown." (Pierce's Code of 1905, sec. 8595, sub. 5.)

11. New Hampshire allows to the owners of land planted with timber or forest trees the following rebate of taxes for a period of thirty years: For the first ten years after planting, a rebate of 90 per cent of all taxes assessed upon the land; for the second ten years, a rebate of 80 per cent, and for the third period a rebate of 50 per cent.[a] (Laws of 1903, chap. 124.)

12. North Dakota grants a bounty of $3 per acre for tracts of prairie land of 1 to 10 acres planted to any kind of forest trees and properly maintained. This bounty may commence one year after planting and is deducted annually from the farm taxes for a period of five years. A bounty is also granted for forest trees planted in hedge rows as boundary lines. The bounty is $2 for 80 rods of hedge row, paid annually for a period of five years. (Revised Codes of 1905, secs. 2082–2085.)

III. BOUNTIES WITHOUT REFERENCE TO TAXATION.

1. Minnesota gives a bounty of $2.50 "per acre for a period of six years" to any person who plants from 1 to 10 acres of prairie land with forest trees and properly maintains them. (Revised Laws of 1905, secs. 2391–2395.)

2. Illinois allows the county commissioners in any county to offer a bounty not to exceed $10 per acre annually for three years to any person who shall plant and properly cultivate 1 or more acres of forest trees. (Revised Statutes of 1908, chap. 136, secs. 1–4.)

3. Kansas also permits the county commissioners in any county to offer a bounty "not to exceed $10 for five years for each acre" to any person who plants and properly cultivates forest trees. The trees must have been kept in thrifty condition for five years before the bounty is payable. (Dassler's General Statutes of 1905, secs. 8605–8608.)

4. Wyoming has a similar law allowing the county commissioners in any county to offer a bounty "not to exceed $10 for five years for each acre" to any person who shall plant and properly cultivate forest trees. The trees must have been kept in thrifty condition five years before the bounty is payable. (Revised Statutes of 1899, secs. 2645–2648.)

IV. PRIZES.

1. Massachusetts requires that every incorporated agricultural society which receives a bounty from the State shall annually offer premiums to encourage the raising and preservation of forest trees. (Revised Laws of 1902, chap. 124, sec. 10.)

2. Vermont provides an annual appropriation of $500 for the Maple Sugar Makers' Association of the State and requires that at least $100 annually shall be spent by the association in premiums for the best maple-sugar products. (Public Statutes of 1906, secs. 340–341.)

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[a] Pennsylvania has allowed a rebate of 80 per cent of all taxes on land containing forest trees with certain restrictions as to number and size of trees, etc., provided that the rebate shall not exceed the sum of 45 cents per acre. (Laws of 1905, chap. 88.) Another Pennsylvania law formerly provided that lands planted to forest trees or maintained with sprout, forest or timber trees, with certain restrictions, shall receive a rebate of 80 per cent of all taxes for a period of thirty-five years from the time the land has been planted or maintained, provided that the rebate shall not exceed 45 cents per acre. (Laws of 1905, chap. 179.) The above statutes were enacted in 1905, taking the place of similar laws which had been in force since 1887, but both statutes have recently been declared unconstitutional. (Tubbs *v.* Tioga County, 32 Penn. County Court Reports, p. 504.)

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CHAPTER III.

FOREST TAXATION IN THE UNITED STATES IN PRACTICE.

I. ADMINISTRATION.

The foregoing discussion of special statutes relating to the taxation of timber lands has shown how little real importance they possess. None of the statutes providing for exemptions, rebates, bounties, and prizes has modified to any extent the burden of the general property tax, or had any important effects on timber lands and the practice of forestry. In studying the practical administration of forest taxation, we are really studying the general property tax itself. The following discussion of methods of administration is therefore very brief, attempting only to give a general survey of the actual administration of the general property tax under which forest lands are taxed.

The administration of the general property tax, being in the hands of local officers, is not exactly the same in any two States or even in any two towns. No attempt will be made here to describe peculiarities of local administration. Certain broad features, however, mark the administration of the general property tax everywhere.

Assessment is in the hands of local officers representing usually the towns but frequently the counties. It is the business of the assessors to make a valuation of the property of every taxpayer in the town or county. The assessor is ordinarily a man possessing no particular technical skill and having no particular facilities for ascertaining the value of property. He is obliged to depend upon the taxpayer's declaration, upon hearsay evidence of one sort and another, and upon occasional examinations of the property which must be at best superficial and inaccurate. The methods of assessment are usually lax. Personal examination of forest lands is made only occasionally at more or less long intervals. Very commonly the tax assessor makes up his books by merely copying from the books of the year before. Even where the assessor uses the best possible methods and the greatest care, the result is bound to be largely a matter of personal judgment. The opportunity for the exercise of personal prejudice is obvious, as is also the opportunity for dishonest collusion with the taxpayer. It should be said, however, that testimony is almost universal to the fact that the local assessors are as a rule honest and faithful officers who endeavor to perform their duties conscientiously and to the best of their ability. The usual motive to undervaluation—the desire to escape as much as possible of the town's burden of State and county taxes—is present wherever the State and county share in the proceeds of the general property tax. This hit-or-miss method of assessment produces the well-known results of inequality, undervaluation, overvaluation, and general confusion. As a rule all property is assessed considerably below its true market value, although this is contrary to law. Assessors usually adopt some fixed ratio of assessed to true value.

The collection of the tax on timber lands is also in the hands of local officers, and involves nothing of special importance in this connection. The rate of the tax is made up of the state, county, and town rates, with sometimes other rates for schools, roads, etc. In a number of States, however, the general-property tax is left to the

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local divisions, in which case there is no state rate. The tax rate varies from place to place. The burden of taxation on any piece of land depends on the tax rate combined with the ratio of assessed to true value.

II. THE BURDEN OF TAXATION.

It is important to know just what is the actual burden of taxation upon timber lands. To thoroughly answer this question would necessitate a detailed study of forest taxation in every State, and indeed in every town where forests are important. This study will take time. Only a beginning has been made as yet. Nevertheless, enough evidence is at hand to enable us to draw some conclusions. These conclusions are, however, only tentative and may possibly have to be modified after further investigation. They are based on (1) an extensive correspondence with tax officials, state foresters, lumber owners, and others; (2) special local investigations made by members of the Forest Service; (3) miscellaneous evidence from forestry journals, lumber-trade journals, the publications of the United States Forest Service, and the several state foresters, and from numerous other sources.

From this evidence, so far as it goes, the following conclusions seem to be warranted:

1. The valuation of forest lands is made in the most haphazard way, resulting in the greatest uncertainty and inequality. For example, a wood lot in New Hampshire was purchased for $1,000. Its assessed value, which had been $400, was immediately raised to $3,000, or three times the purchase price. The tax rate in this town was 1.85 per cent. Assuming that the purchase price represented the true value of the property, it was required to pay a tax every year of 5½ per cent of its value. In this particular case the owner made no complaint, for the reason that he believed this excessive tax was counterbalanced by undervaluation of some of his other lots, an interesting commentary on the results of local assessment.

As an example of undervaluation we may cite another piece of timber land in New Hampshire which was sold for $15,000. Its assessed value at the time was $500, or one-thirtieth of the selling price. Even after the sale, its assessed value was raised only to $1,100.

Here is an interesting example of unequal assessment. Two adjoining tracts in New Hampshire were estimated by the Forest Service investigator to be of about equal value. The first, which was if anything the more valuable of the two, was assessed at $500; the second at $3,500, or seven times the other.

2. The above examples are extreme cases, though similar cases are common enough. What we are more especially interested in is the prevailing burden of taxation in the general run of ordinary cases. The facts seem to be as follows: In some States or regions the prevailing burden of taxation on timber lands is undoubtedly very heavy. There is a good deal of evidence showing excessive taxation of timber lands in parts at least of the States of Michigan, Wisconsin, Minnesota, and the States of the Pacific coast. On the other hand, there are States where the prevailing taxation of timber lands is decidedly lenient. Individual cases of unduly lenient and excessively heavy taxation are common, probably everywhere. Leaving out of consid-

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eration individual cases, and without going into local conditions, it is safe to say that in general timber land, like most other property, is grossly undervalued by the assessors. Probably, until very recently at any rate, timber land has been assessed relatively lower than agricultural land. This assessment is combined with a high tax rate; that is, a rate which would generally result in excessive taxation if the property were assessed at its true value. As a general rule, however, due to the prevailing underassessment and the lax administration of the laws, timber lands are not subjected to an excessive burden of taxation. In the great majority of cases investigated the annual tax was less (usually very much less) than 1 per cent of the true value.

3. A third conclusion that stands out distinctly is that there is at present in many places an unmistakable tendency toward heavier taxation of timber lands. This tendency is seen especially in those regions where forests have heretofore been admittedly taxed very gently, such as the wild lands in the unincorporated parts of Maine and New Hampshire. Here there is considerable complaint of the escape of wealthy timber owners from their just share of taxation, and a growing demand for amendment to the statutes which will put a heavier tax upon these lands. On the other hand, the movement toward heavier taxation is seen in the common tendency to value timber lands more accurately and enforce the existing laws more strictly. It should be remembered, however, in connection with the tendency to increase the assessed valuation of timber lands, that there has been a very great increase in the real values of lumber and timber lands within recent years.

The evidence on this subject, though far from complete, is still quite extensive. Part of this evidence is presented in the appendix to this chapter, together with some analysis and discussion.[a] Some further incidental light on this problem may be obtained from the testimony of lumbermen presented in the appendix to the next chapter.[b]

APPENDIX.

EVIDENCE AS TO BURDEN OF TAXATION ON FORESTS.

I. SOURCES OF EVIDENCE.

The conclusions in the text regarding the present burden of taxation upon forests in the United States are based upon a mass of evidence, the principal sources of which are the following: (1) Letters from local tax assessors and other officers received in reply to a schedule of inquiry sent out by the Forest Service under the writer's direction; (2) letters from state foresters, tax commissioners, and other authorities received in reply to a letter of inquiry sent out by the International Tax Association; (3) special local investigations made by members of the Forest Service; (4) miscellaneous evidence from forestry journals, lumber-trade journals, and publications of the United States Forest Service and the several state foresters; (5) an extensive correspondence by the Forest Service and by the writer; and (6) interviews with a number of persons having special knowledge of the subject. In this appendix is presented, with some analysis and discussion, some of the more important parts of this evidence.

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[a] See Appendix to Chapter III, p. 592.
[b] See Appendix to Chapter IV, p. 608.

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II. NEW HAMPSHIRE.

The State for which we have the best evidence is New Hampshire. A careful study of taxation of timber lands in this State has been made by Mr. J. H. Foster, of the Forest Service, and a large amount of valuable material gathered. This material makes it possible to present a fair idea of the actual burden of taxation borne by timber lands in New Hampshire.

For this purpose the State naturally divides itself into two parts. The southern part is the prevailing wood-lot section; in general, the lots are not of great size and they are situated in well-settled incorporated towns. In the north, although here, too, we find many wood lots, a large part of the forests is owned by lumber and paper companies, institutions, estates, and persons of large means. Much of this land is located in unincorporated places.

The average tax rate for all the incorporated towns of the State in 1907 was 1.99 per cent.[a] For each county the average rate for the incorporated towns is shown in the following table:[b]

New Hampshire tax rates, 1907.

	Per cent.
Average for the State	1.99
Rockingham County	2.11
Strafford County	1.95
Belknap County	2.29
Carroll County	1.95
Merrimack County	2.02
Hillsboro County	1.87
Cheshire County	1.77
Sullivan County	2.09
Grafton County	2.23
Coos County	2.14

The prevailing rates in the several towns lie between 1.5 and 2 per cent. Of the 235 towns in the State, 113, or 48 per cent, have rates ranging from 1.51 to 2; 45 towns, or 19 per cent, have rates from 1 to 1.5; and 54 towns, or 23 per cent, have rates from 2.01 to 2.5; 21 towns, or 9 per cent, have rates above 2.5. The lowest rate in any town is 0.7, and only one other town has a rate below 1 per cent. The highest rate is 3.28, and only one other town has a rate above 3 per cent. The rate in the unincorporated places was 0.4 in 1907. These places have a very low rate on account of not having to pay town taxes.

The valuation of timber lands is made by local assessors in the incorporated towns and by the state board of equalization, with the assistance and advice of the county commissioners in the unincorporated places. Throughout the State timber lands are assessed far below their true value. From several hundred examples investigated, the following cases are given. These are cases in which the true values were ascertained with some accuracy.

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[a] Valuation and Taxation of the State of New Hampshire for the Year 1907; Compiled by the Secretary of the State Board of Equalization, p. 83.

[b] Ibid.

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Assessed valuation and true value per acre, 1908.

	Assessed valuation.	Estimated true value.	Percentage of assessed to true value.
CENTRAL WOOD-LOT REGION.			
Case 1	$6.50	$30.00	21.7
Case 2	53.00	104.00	51.0
Case 3	10.00	50.00	20.0
Case 4	50.00	64.00	78.1
Case 5	3.00	30.00	10.0
Case 6	39.00	60.00	65.0
Case 7	8.50	22.00	38.6
Case 8	3.00	50.00	6.0
Case 9	37.50	70.00	53.5
SOUTHERN WOOD-LOT REGION.			
Case 10	50.00	80.00	62.5
Case 11	13.00	23.00	56.5
Case 12	40.00	100.00	40.0
Case 13	16.00	40.00	40.0
Case 14	35.50	150.00	23.6
Case 15	18.00	52.00	34.6
Case 16	95.00	150.00	63.3
Case 17	13.50	34.00	39.7
Case 18	11.50	36.00	31.9
Case 19	2.30	10.00	23.0
Case 20	30.00	50.00	60.0
Case 21	20.00	75.00	26.6
Case 22	54.00	90.00	60.0
Case 23	66.00	100.00	66.6
Case 24	57.00	128.00	44.5
Case 25	90.00	325.00	27.6
Case 26	50.00	60.00	83.3
Case 27	23.00	30.00	76.6
WILD LANDS IN SOUTHERN TOWNS.			
Case 28	5.00	40.00	12.5
Case 29	5.00	30.00	16.6
Case 30	23.00	66.00	34.8
Case 31	70.00	150.00	46.6
WILD LANDS IN NORTHERN TOWNS.			
Case 32	30.32	35.00	86.6
Case 33	4.70	35.00	13.4
Case 34	5.00	40.00	12.5
Case 35	11.61	50.00	23.2
Case 36	15.00	30.00	50.0
Case 37	7.00	35.00	20.0
Case 38	8.60	60.00	14.3
Case 39	7.00	40.00	17.5
Case 40	6.00	35.00	17.1
Case 41	6.00	60.00	10.0
Case 42	4.70	35.00	13.4
Case 43	15.00	60.00	25.0
Case 44	8.00	75.00	10.6
Case 45	4.00	20.00	20.0
Case 46	8.50	50.00	17.0
Case 47	3.00	10.00	30.0
WILD LANDS IN UNORGANIZED PLACES.			
Case 48	15.14	20.00	75.7
Case 49	10.85	25.00	43.4
Case 50	5.72	20.00	28.6
Case 51	10.25	25.00	41.0
Case 52	19.43	30.00	64.7
Case 53	2.50	30.00	8.3
Case 54	8.00	25.00	32.0
Case 55	17.39	25.00	69.5
Case 56	15.08	30.00	50.2

An analysis of these figures gives a fair idea of the prevailing undervaluation of timber lands throughout the State. There are 56 examples in all. The average ratio of assessed to true value is 37.7 per cent. The closest approach to true value was made in the case where the forest was assessed at 86.6 per cent of its estimated true value. The lowest assessed valuation is 6 per cent. Of the 56 cases only 16 were assessed above 50 per cent of their true value and 21 cases were assessed below 25 per cent. In round numbers, more than two-

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thirds of these 56 forest properties were assessed at not more than one-half of their true value; three-eighths of the properties were assessed at less than one-fourth of their true value; and the average assessment for all 56 cases was only a little more than one-third of the true value.

The assessment varies somewhat with the region. It is highest in the wild lands of the unorganized parts of the State and in the southern wood-lot region. Of the cases in organized towns, about three-fourths were assessed at not more than one-half their true value, nearly half at less than one-fourth their true value, while the average assessment for all cases was only a little over one-third of the true value. An analysis of the examples according to region is given in the table below.

Percentage of assessed to true value, 1908.

Region.	Number of cases.	Average.	Highest.	Lowest.	Cases above 50 per cent.	Cases below 25 per cent.
Central wood lot	9	38.3	78	6	4	4
Southern wood lot	18	48	83	23	8	2
Wild lands in towns of South	4	28	47	17	0	2
Wild lands in towns of North	16	23.8	87	10	1	12
Wild lands in unorganized places	9	46	76	8	3	1
All cases in towns	47	36.2	87	6	13	20
Total	56	37.7	87	6	16	21

Extending this investigation, by taking in a number of examples where the true value can not be accurately determined and yet may be roughly estimated, produces results which agree substantially with the above. An investigation of something over 100 examples of wood lots in southern New Hampshire, estimating the true values roughly but very conservatively, shows that in fully three-fourths of the cases the assessed valuation is not greater than half the true value. In one-third of the cases the assessed value is less than one-fourth of the true value. There are a few extreme cases, both of high and of low valuations, but only three or four cases where the valuation appears to exceed the true value. There are a good many more cases where the property is ridiculously undervalued.

A similar investigation of a number of examples of wild lands in towns of northern New Hampshire shows a still lower basis of assessment. Hardly any cases appear where the assessment is more than half the true value. About half the examples were assessed at less than one-fourth the true value. the other half being assessed between one-fourth and one-half of the true value. A large number of cases appear where the assessment is only 10 per cent of the true value or even less. These results agree with the figures above based on cases where the true values were more accurately determined.

Having before us the facts regarding the tax rate and the ratio of assessed to true value, we are in a position to determine the actual burden of taxation on the forests of the State. The average tax rate of the towns in 1907 was 1.99 per cent. The average ratio of assessed to true value in the examples from towns was 36.2 per cent. Combining these figures would show an average tax of 0.72 per cent of the true value, or a little less than three-fourths of 1 per cent.

Again, 48 per cent of the towns have tax rates from 1.5 and 2, and another 19 per cent have rates from 1 to 1.5. Also, three-fourths of the cases of taxation in organized towns showed assessed valuations of not more than half the true value. These figures furnish a fair presumption that a large majority of forest properties are taxed at something less than 1 per cent of their true value.

A more satisfactory way of approaching this question is by an analysis of all the individual examples where it is possible to combine the tax rate and the ratio of assessed to true value. From about 150 such examples the following results are obtained. These results are in some cases based on fairly accurate knowledge of true values; the majority are based on more or less rough estimates of true value.

Less than one-fifth of the cases show a tax rate exceeding 1 per cent of the true value. The other four-fifths may be divided roughly into three equal

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groups. About one-fourth of the cases show rates from one-half of 1 per cent to 1 per cent; another one-fourth shows rates from one-fourth to one-half of 1 per cent; while one-fourth again shows rates below one-fourth of 1 per cent. In slightly more than half the examples the taxes do not exceed one-half of 1 per cent of the true value. These examples also show the relatively lower burden of taxation in the northern part of the State, where in nearly three-fourths of the cases the taxes are not over one-half of 1 per cent of the true value.

In the unincorporated parts of the State timber lands are taxed very leniently. With a tax rate of only four-tenths of 1 per cent, it hardly requires further evidence to show that the taxes are not heavy, even though the property were assessed at its full value, which is rarely, if ever, the case. The ratio of assessed to true value is, indeed, relatively high in the unorganized places.[a] The nine examples given showed an average ratio of 46 per cent. This would give an average tax of a little less than one-fifth of 1 per cent of the true value. Only a few examples showing the true value are available. Of these, the large majority pay taxes which are less than one-fourth of 1 per cent of the estimated true value of the property.

Thus far the attempt has been made to present the general situation in New Hampshire with regard to the burden of the general property tax on forest lands. Extreme and peculiar cases have not been discussed; we have described rather the condition of the general run of ordinary cases. Needless to say, there are plenty of cases that are peculiar in one way or another, and a glance at a few individual examples, taken more or less at random, may bring out a number of important and interesting side lights on this subject.

Several examples show a decidedly small burden of taxation. One tract of 200 acres in the mountains of southern New Hampshire covered with mature spruce has been assessed for years at $1,000. Recently the tract was sold for $5,000 and ten days later for $8,000.

In a certain town a farmer owns a number of lots in different parts of the town, worth altogether about $40,000. Outside the farm on which he lives, he is assessed for only $1,200. Apparently the assessors know very little about his valuable wood lots.

A certain old farm of 200 acres in southern New Hampshire has been assessed for the last twenty years at $500. In 1906 the assessors decided that this was too low and raised the valuation to $1,000. Since then the farm has been sold for $13,000 and it is now being assessed for $10,000.

Another wood lot was assessed at $250. Some one complained that this lot was not being taxed enough and the assessment was raised to $1,200. Soon after a lumberman paid $6,000 for the timber alone, leaving the farm still worth as much as $1,200.

A valuable piece of timber land about which the assessors apparently had little information was sold to a lumber company for $15,000. Its assessed valuation at the time was $500. Even after the sale the assessed value was raised only to $1,100.

Some equally interesting examples show what is undoubtedly excessive taxation. A lot of 1,628 acres in northern New Hampshire was assessed in 1906 at $3,300 or about $2 per acre. Next year the valuation was raised to $3.42 per acre, and in 1908 was increased to $50,000, or an average of $30.32 per acre. The paper company which owns this tract has complained against this assessment, and it is said that they are willing to sell the tract for $10,000, or one-fifth its assessed valuation.

Four lots in a town of northern New Hampshire were assessed for a number of years at $700 each. The owner tried to sell the lots for this price, but was unable to find a buyer. They were finally sold for $500. As the tax rate in this town was 2.25 per cent, this means a decidedly heavy burden of taxation.

A water company in a town of southern New Hampshire is assessed $100,000 on 70 acres of land and improvements. The improvements are estimated as worth $60,000, leaving an assessed valuation of $40,000 on 70 acres of land, or an average valuation of $571.43 per acre. The tax rate in this town in 1907 was 1.55 per cent.

A wood lot in northern New Hampshire, containing 250 acres, was bought at auction for $1,400. Soon after the assessed valuation, which had been very low, was increased to $1,800. Part of the timber was then cut off and sold, but

[a] See table above, p. 594.

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the valuation was further increased to $2,100. This property is probably not worth its assessed valuation. As the tax rate in the town is 2.95 per cent, this means a decidedly heavy tax.

A wood lot in southern New Hampshire was purchased for $1,000. It had previously been assessed at $400, but this valuation was immediately raised to $3,000 or three times the purchase price. The tax rate in this town in 1907 was 1.85 per cent. Assuming that the purchase price represented the real value of the lot, this lot is taxed over 5½ per cent of its value every year. In this particular case, the owner made no complaint, for the reason that he believed this excessive taxation was counterbalanced by undervaluation on some of his other lots.

The cases given above have illustrated not only the possibility of very heavy and very light burdens of taxation, but have also served to show the arbitrary and uncertain character of the prevailing methods of assessment. They show how eagerly the sale of a piece of property is seized upon by the assessors as evidence showing its value, which apparently had been only guessed at before. It may be worth while here to refer to some other examples showing the general character of assessment.

Two wood lots in southern New Hampshire were carefully examined and compared with each other. The lots were of the same general character, about equally distant from town, and apparently of about the same value; each was recorded in the tax books as containing 25 acres. One was assessed, however, for $800 and the other for $1,500.

Another example showing unequal assessment is that of a wood lot of 100 acres and an adjoining farm and wood lot in a town of southern New Hampshire. The 100-acre wood lot is probably somewhat more valuable than the adjoining farm and wood lot; yet the former is assessed at $500 and the latter at $3,500.

In some places the assessors purposely undervalue timber lands for the reason that the forests in the neighborhood of summer resorts add to the attractiveness of the region and therefore to the profits of the inhabitants. It is wished to encourage such natural advantages by a low burden of taxation. The evidence shows that in some towns such forest tracts are practically untaxed through the force of public opinion. For example, two lots in such a town were assessed at $500, while their true value is shown by their later sale for $5,800.

Reference has been made to the eagerness with which sales are seized upon by the assessors as giving evidence of the value of timber land. Two other examples of this may be of interest. A timber tract in southern New Hampshire was sold in 1905 for $12,000. Up to that time it had been assessed at $900. After the sale this valuation was raised to $4,000, still, however, only one-third of the purchase price. A wood lot which was sold in 1907 for $7,000 had been assessed up to that time at $500. After the sale the valuation was raised to $3,500. The owner complains that he is overtaxed in spite of the fact that his assessed valuation is only one-half the price paid for the land.

Almost every example of successive assessments for a number of years shows the striking tendency toward increased valuations during recent years. We may cite a few such cases by way of illustration.

A tract of 100 acres in Cheshire County, of which about 80 acres are covered with a good growth of pine, was assessed in 1897 at $1,000, in 1899 at $1,300, in 1900 at $1,600, in 1901 at $2,000, in 1902 at $2,300, in 1904 at $3,250, in 1905 at $4,500, in 1906 at $5,000,[a] and finally in 1908 at $7,000.

One of the most striking cases of increased valuation occurred in one of the upper Connecticut Valley towns. This town raised its valuation on timber lands $90,000 in 1908. Expert estimators were employed to value the timber. The valuations were considered decidedly lenient, yet the assessment of one company was raised from $3,050 to $16,000, that of another company from $5,000 to $50,000, while one small wood lot was raised from $250 to $4,000.

In a certain town of northern New Hampshire the total "nonresident valuations" of timber lands have been raised since 1892, as is shown by the following figures:

1892	$37,018
1902	43,980
1904	88,572
1905	112,368
1908	267,500

[a] New Hampshire Forestry Commission, Report 1905–6, p. 206.

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A tract of 10,000 acres in northern New Hampshire was valued in 1890 at $6,000, in 1895 at $10,000, in 1900 at $20,000, in 1905 at $30,000, and in 1908 at $60,000, a tenfold increase in eighteen years.

A certain tract in the unincorporated part of the State was assessed in 1902 at $200,000 and four years later for $325,000. In 1890 the valuation was only $25,000.

A certain city in southern New Hampshire undertook to assess its timber lands carefully after a thorough valuation by a board of experts. Having obtained as nearly as possible the true value of each lot, its assessed value was placed on the books at about 60 or 70 per cent of the estimated true value. The result of this method of assessment was to enormously increase the assessed valuations. Out of 24 examples taken from the tax books of this town only three cases appear where the increase was less than 100 per cent. In these cases the valuations were increased, respectively, 40 per cent, 66 per cent, and 66 per cent. In five cases the valuation was doubled, in five cases trebled, and in the other cases increased still more. In one case the assessment was eight times what it was before. This example is good evidence of the prevailing undervaluation of timber lands and of the result that would follow strict assessment according to true value, and it should be remembered that in this case the assessed valuation was purposely put at about two-thirds of the estimated true value.

In conclusion, this investigation of conditions in New Hampshire serves to demonstrate (1) that the assessment of timber lands is more or less arbitrary and uncertain, often being a matter of mere guesswork; (2) as a result there are many individual cases of ridiculously low valuation and some cases of excessive valuation; (3) that in the general run of cases the burden of taxation is decidedly moderate; (4) and, finally, that there is a tendency toward higher assessment and heavier taxes. These conclusions receive further support from the report of the New Hampshire Tax Commission of 1908.[a]

III. OTHER NEW ENGLAND STATES.

It is unfortunate that such extensive evidence as exists in the case of New Hampshire is not available from other States. It is hoped that as this study progresses similar material may be collected from at least all of the other important timber-producing States. For the present we must be content to draw what conclusions we can from the testimony that is available from other parts of the country.

Considerable miscellaneous evidence seems to warrant the conclusion that the general situation in Maine is substantially similar to that of New Hampshire. Here also we find a large territory which is not incorporated and has no town taxes to pay. The most important facts regarding the taxation of these lands are shown in the following quotation:[b]

"A late estimate places the total amount of wild land in Maine at 18,000 square miles, three-fourths of which is not incorporated. The unincorporated townships are in Aroostook, Franklin, Hancock, Penobscot, Piscataquis, Oxford, Somerset, and Washington counties, the value of which is fixed once every two years by the state assessors, and forms the valuation on which the state and county taxes are based. These unincorporated lands are subject to the same rate of state and county taxes as property located in cities and towns. In addition, the owners of wild land pay for the building and maintenance of all highways. In 1870 the total valuation of the unincorporated townships was fixed at $5,156,356, an average of 55 cents an acre. In 1880 the value was increased to $7,984,060, an average of 92 cents an acre. In 1890 the valuation was raised to $19,146,458, or by more than 100 per cent, the average value of each acre being $2.07. The state board of assessors was created in 1901, its first assessment made in 1902, since which time the unincorporated townships have been assessed $11,660,070, or 51 per cent more than in 1890. During the same period other property in the State has increased in value only 13 per cent."

This increase has continued till at present the wild lands are valued by the state assessors at $37,559,000. The State and counties derive from them an annual income of about $186,000.

The tax rate in the unincorporated places is made up of a uniform state rate of 3 mills, and a county rate varying from 1 to 5 mills and averaging 2

[a] N. H. Tax Commission Report, 1908, pp. 175–199.
[b] American Lumberman, Sept. 22, 1906, p. 26.

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mills. The total tax rate is therefore in the neighborhood of 5 mills, or one-half of 1 per cent. This tax, combined with the evidently low valuation, means a very light burden of taxation. There has of late been considerable popular complaint against the relatively small taxes paid by the large lumber and paper companies and other wealthy owners of wild lands in the unincorporated parts of the State. A good deal of agitation in favor of higher taxes has resulted. At the last session of the legislature a commission was appointed to investigate the general subject of taxation, having this idea particularly in view. A plank in the Democratic platform in the State campaign last fall demanded higher taxation of wild lands. A most decided tendency to increase the valuation of wild lands is shown in the figures given above. It should be remembered, however, that there has been a great increase in actual values during recent years.

In the incorporated towns of the State the average tax rate is about 21 mills,[a] or 2.1 per cent. This is slightly higher than in New Hampshire. In the absence of statistical data as to the relation between assessed valuation and true value, we can not determine definitely the burden of taxation. There seems, however, to be no widespread complaint of excessive taxation.

The data in the other New England States are not sufficient to warrant any positive conclusions as to the burden of taxation on timber lands. Occasional cases of excessive taxation are on record, as well as occasional cases where the owner admits his taxation is very light. There seems to be no evidence showing that timber lands are generally subjected to an excessive burden of taxation or that any widespread dissatisfaction exists. The following quotation is of interest in this connection:[b]

"In general, the assessment of white-pine lots is moderate, or even low, in comparison with the sale value. The rate of taxation varies exceedingly, but generally falls between $1.50 and $2 per hundred dollars valuation. The rate in some towns is as low as $1.20, but occasionally it reaches $3. Local taxation is controlled by the town, and the assessment and the rate depend upon the condition of the town's finances. The building of a new bridge or a schoolhouse often causes the tax rate to be raised considerably for a time. The valuation of the property is made by a local board of assessors, which frequently includes the valuation of a pine-wood lot in that of the whole farm of which it is a part. No exact rule exists with regard to the age at which a growing stand of pine shall begin to be taxed. Sometimes the assessors double or treble the valuation of a pine lot within a short period of years. Property is usually supposed to be revalued at stated intervals of eight or ten years, but this is not often regularly done.

"A high valuation or a heavy tax rate forces the owner to cut his pine lot at once. Towns where high taxes are levied on woodland are usually devoid of timber. Local assessors are beginning to learn, however, that a reasonable valuation and a moderate tax on pine lots for a considerable number of years mean a greater total income to the town than one heavy tax which compels the owner to cut his wood lot.

"Upon the whole, there is no great injustice practiced under the present method of taxation. Its greatest fault lies in the lack of a stable, regular system by which the valuation shall be fairly made and regularly increased according to the age and value of the stand, so that the owner may know whether he can afford to keep his stand and allow it to grow another ten years, when that period means a large proportionate increase in its yield."

The subject of forest taxation was investigated by a legislative committee in Massachusetts in 1905, but their report gives no data as to the actual burden of taxation on timber lands.[c]

IV. LETTERS FROM LOCAL ASSESSORS AND OTHER OFFICERS.

Some important material has been obtained from letters of local tax assessors, town and county officers, and others. These letters are in reply to a schedule of questions sent out by the Forest Service. Information has thus been received from 175 counties of Alabama, California, Iowa, Louisiana, Maryland, Michigan, Minnesota, New York, North Carolina, Pennsylvania, and

[a] American Lumberman, Sept. 22, 1906, p. 26.

[b] Forest Service Bulletin, No. 63, p. 31.

[c] Report of Committee of 1905 to Consider the Laws Relative to the Taxation of Forest Lands. Massachusetts State Forest Service, Bulletin No. 3.

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Washington. With reference to the particular subject of this chapter, these statements show for each county (1) the lowest, and (2) the highest, assessed valuations of timber lands; (3) the assessed valuation of what are considered representative tracts of timber land; (4) the estimated true value of representative tracts; (5) the total tax rate (state, county, town, etc.); (6) the fixed ratio of assessed valuation to true value, and (7) the ratio of the tax to the true value of the land. These figures, which are given in full in Table B following, speak for themselves, and discussion is hardly necessary. So far as they go, they show the wide range in the valuation of timber lands which we should naturally expect; they show that timber lands are valued for taxation far below their true value; and they show the well-nigh universal custom of assessing property considerably below its true value, generally at some fixed ratio.

The general conclusions to be drawn from these figures will appear more clearly from Table A below, where the results are summarized by States. For example, in 21 counties of Alabama representative tracts of timber land are assessed at from $1 to $20 per acre, the true values ranging from $1.25 to $25. The tax rate varies in the several counties from 1.15 per cent to 1.50 per cent. The ratio of assessed to true value ranges from 25 per cent to 75 per cent, though for nearly all the counties it is between 50 and 60 per cent, the average for all counties being 58 per cent. The ratio of tax to true value averages 0.79 per cent and is less than 1 per cent in every county. The table shows the corresponding facts for each of the other States. These figures seem to show heavy taxation in California, Michigan, and Washington, rather heavy in Iowa, Louisiana, Minnesota, and Pennsylvania, and a light burden in Alabama, Maryland, New York, and North Carolina.

TABLE A.

State.	Number of counties.	Assessed value of representative tracts.	True value of representative tracts.	Tax rate.	
				Range.	Average.
				Per cent.	*Per cent.*
Alabama	21	$1.00–$20.00	$1.25–$25.00	1.15–1.50	1.35
California	19	2.00–100.00	5.00–200.00	1.00–3.55	1.89
Iowa	20	1.00– 70.00	20.00–140.00	.35–5.00	2.71
Louisiana	24	1.00– 25.00	3.00– 75.00	1.00–3.50	2.03
Maryland	1	3.00– 20.00	20.00– 50.00	1.31	1.31
Michigan	18	4.00–100.00	5.00– 80.00	.86–4.13	2.18
Minnesota	18	2.00– 12.00	7.00–200.00	.84–4.20	2.55
New York	10	2.00– 50.00	3.00– 60.00	.20–1.90	.66
North Carolina	22	3.00– 20.00	4.00– 50.00	.60–1.30	.90
Pennsylvania	11	1.00– 50.00	1.00– 75.00	.40–3.20	1.45
Washington	11	1.02– 17.92	.75–100.00	1.38–3.50	2.63

State.	Number of counties.	Ratio of assessed to true value.		Ratio of tax to true value.			
		Range.	Average.	Range.	Average.	Number of counties having ratio of—	
						1 per cent or over.	Less than 1 per cent.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*		
Alabama	21	25– 75	58	0.35–0.98	0.79	0	20
California	19	20–100	63	.37–1.64	1.17	15	4
Iowa	20	20–100	45	.28–2.55	1.06	8	10
Louisiana	24	25– 75	47	.33–2.10	.95	8	14
Maryland	1						
Michigan	18	50–100	71	.43–3.00	1.46	6	4
Minnesota	18	20– 60	38	.28–2.40	.96	4	8
New York	10	50– 75	66	.11–1.46	.63	1	5
North Carolina	22	25–100	58	.17–1.30	.51	1	15
Pennsylvania	11	33–100	71	.27–1.90	.89	3	6
Washington	11	25– 60	47	.34–2.06	1.30	5	1

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TABLE B.—*Showing assessed valuation and true value of timber lands; also tax rate, fixed ratio of assessed to true value, and ratio of tax to true value, in certain States and counties, 1908.*

State and county.	Assessed valuation per acre.			4. True value per acre, representative tracts.	5. Total tax rate.	6. Fixed ratio of assessed to true value.	7. Ratio of tax to true value.
	1. Lowest.	2. Highest.	3. Representative tracts.				
ALABAMA.					*Per cent.*	*Per cent.*	*Per cent.*
Autauga	$5.00	$15.00	$5.00–$20.00	.....	1.35	60	0.81
Bibb	10.00	20.00	.....	.....	1.3	50	.65
Bullock	.....	.....	.....	.....	1.175	60	.71
Clarke	3.00–5.00	10.00	3.00– 10.00	$20.00	1.3	50–75	.65–.98
Clay	2.00	10.00	3.00	5.00	1.5	60	.90
Conecuh	5.00	13.00	10.00– 12.50	20.00– 25.00	1.5	50–60	.75–.90
Dale	5.00	15.00	.....	.....	1.4	60	.84
Escambia	2.50	8.50	4.00	6.00	1.4	60	.84
Greene	1.00	2.50	1.50	2.00– 3.00	1.25	75	.94
Henry	3.00	5.00	3.00	25.00	1.4	25	.35
Jefferson	3.00	10.00	5.00	8.00	1.3	60	.78
Lamar	1.00	2.50	2.00	3.00	1.4	50	.70
Lee	.....	.....	.....	.....	1.3	60	.78
Macon	4.05	4.05	4.05	.....	1.15	60	.69
Madison	1.00	15.00	.....	.....	1.45	60	.87
Marshall	.50	3.00	3.00	1.50	1.5	60	[b].90
Mobile	1.50	2.50	2.00	10.00	1.2	.....	.....
Monroe	3.00–5.00	10.00–15.00	5.00– 10.00	.....	1.5	[a]	[b]
St. Clair	1.00	3.00	1.00	1.25	1.35	60	.81
Sumter	4.00	6.00	6.00	10.00	1.35	60	.81
Talladega	3.00	8.00	6.00	10.00	1.25	67	.84
CALIFORNIA.							
Alpine	2.00	1.25	2.50	5.00	2.25	50	1.13
Amador	3.00	5.00	5.00	10.00	2.0	50–60	1–1.20
Colusa	2.00	50.00	2.00– 50.00	5.00–100.00	1.6	50	.80
Glenn	7.00	12.00	10.00	18.00	1.86	60	1.12
Humboldt	5.00	80.00	5.00–100.00	8.00–200.00	2.0	60	1.20
Kings	5.00	50.00	25.00	40.00	1.65	67	1.11
Lassen	3.50	12.50	3.50– 12.50	3.50– 12.50	1.8	60	1.08
Modoc	3.00	8.00	6.00	9.00	1.98	67	1.33
Napa	[c]	[c]	[c]	[c]	1.62	67	1.09
Orange	[d]	[d]	[d]	[d]	1.7	40	.68
Placer	.....	.....	5.00	10.00	2.0	67	1.34
Riverside	5.00	.....	5.00– 10.00	20.00– 50.00	1.85 3.55	20–35	.37 .71 .65–1.24
Siskiyou	6.00	7.00	6.00– 7.00	10.00– 20.00	1.62	60	.97
San Benito	.....	.....	.....	.....	2.0	60	1.20
San Luis Obispo	.....	15.00	.....	.....	1.9	60	1.14
Santa Clara	[e]	[e]	[e]	[e]	1.64	100	1.64
Shasta	5.00	8.00	8.00	10.00– 50.00	2.1	75	1.58
Tehama	2.50	8.00	2.50– 8.00	.....	1.6	100	1.60
Tuolumne	5.00	100.00	10.00	.....	2.0	67	1.34
IOWA.							
Adair	4.00	6.00	4.00	25.00	3.0	25–33	.75–.99
Appanoose	15.00	20.00	16.00	20.00	3.35	80	.28
Cedar	4.00	40.00	4.00–40.00	20.00–100.00	2.5	60	1.50
Decatur	5.00	40.00	5.00–10.00	20.00– 40.00	3.51	20	.70
Delaware	1.00	40.00	.....	.....	3.5	25	.88
Grundy	44.00	56.00	53.00	100.00	1.6	50	.80
Hamilton	.....	.....	.....	.....	2.5 3.4	25	.63 .85
Hardin	.....	.....	40.00	60.00	.....	.....	.....
Henry	15.00	20.00	40.00	140.00	2.99	33	.99
Iowa	.....	.....	10.00–30.00	30.00–75.00	3.0	33–50	.99–1.50
Jasper	4.00	80.00	60.00–70.00	95.00	2.5	25	.63
Mahaska	.....	.....	.....	.....	.....	67	.....
Mills	20.00	40.00	20.00	45.00	3.0	67	2.01
Monona	.....	.....	.....	.....	3.0	20–85	.60–2.55
Montgomery	16.00	36.00	.....	.....	3.0	50	1.50
Page	24.00	37.00	41.00	50.00	2.7	25	.68
Pocahontas	[f]	[f]	38.57	50.00	2.95	50	1.48
Shelby	1.00	1.00	1.00	.....	1.84	25	.46
Sioux	.....	.....	.....	.....	1.45	100	1.45
Webster	20.00	39.00	37.50	50.00	5.	25	1.25

[a] More than 60 per cent. [b] More than 90 per cent. [c] No timber land.
[d] No timber land assessed separately. [e] Mostly cut over. [f] Little timber.

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TABLE B.—*Showing assessed valuation and true value of timber lands; also tax rate, fixed ratio of assessed to true value, and ratio of tax to true value, in certain States and counties, 1908*—Continued.

State and county.	Assessed valuation per acre.			4. True value per acre, representative tracts.	5. Total tax rate.	6. Fixed ratio of assessed to true value.	7. Ratio of tax to true value.
	1. Lowest.	2. Highest.	3. Representative tracts.				
LOUISIANA.					*Per cent.*	*Per cent.*	*Per cent.*
Bossier	$5.00	$5.00	$5.00	$10.00	1.3 2.55	50	0.65 1.28
Calcasieu	5.00	17.00	12.00	36.00	2.05	33	.68
Caldwell	2.50	10.00	2.50–10.00	4.00–15.00	2.0 2.5	50–75	1.00 1.20 1.50 1.88
Cameron					1.5	50	.75
Catahoula	2.00	17.00	2.00–17.00	4.00–40.00	1.5 2.5	50	.75 1.25
Claiborne	2.00	3.00	2.40	5.00	1.8	50	.90
East Feliciana					1.35	50	.68
Franklin	2.00	10.00	4.00	8.00–12.00	1.6 1.8	50	.80 .90
Grant	5.00	17.00	5.00–17.00	15.00–50.00	1.0	33⅓–50	.33⅓–.50
Iberville	10.00	20.00	10.00	25.00	2.6	40	1.04
Jefferson	10.00	50.00	25.00	50.00	2.7	50–67	1.35–1.81
Lafayette	5.00	8.70	8.70	25.00	2.0		
Lincoln	2.35	2.35	2.35		2.0 2.5	33	.66 .83
Livingston	5.00	20.00	5.00–20.00	25.00–30.00	1.3	60	.78
Morehouse	5.00	10.00–12.00	2.00–10.00	40.00–60.00	2.3	40–60	.92–1.38
Nachitoches	5.00	17.00	5.00–17.00	8.00–30.00	2.55	50	1.28
Ouachita	1.25	5.00	5.00	10.00	1.8	50	.90
St. Bernard	5.00	5.00	1.00– 5.00	3.00–10.00	3.5	60	2.10
St. Martin	5.00	20.00	12.33⅓	50.00	2.5	33⅓	.83
Tensas	2.00	15.00	2.00–10.00	5.00–15.00	2.5	50	1.25
Terrebonne	5.00	20.00	5.00–20.00	10.00–40.00	2.55		
Vernon	2.00	17.00	5.00–17.00	10.00–75.00	1.5 2.5	25–33⅓	.38 .63 .50 .83
Washington	5.00	17.00	10.00	20.00	1.5	25–50	.38–.75
West Feliciana	1.50	10.00			1.0	33⅓	.33
MARYLAND.							
Caroline	3.00	20,00	3.00–20.00	20.00–50.00	1.31		
MICHIGAN.							
Alger	1.50	10.00	6.00	10.00	3.44	50	1.72
Allegan	1.00	5.00	40.00–60.00	40.00–80.00	1.0 2.0	75–80	.75 .80 1.50 1.60
Antrim	20.00	50.00	35.00	35.00	3.0	100	3.00
Bany					3.0	90	2.70
Benzie	12.00	25.00	20.00			100	
Gratiot						67	
Hillsdale	15.00	20.00			.9 1.25	50–75	.45 .63 .68 .94
Huron						67	
Kent	50.00	100.00	75.00–100.00	75.00	1.0	100	1.00
Mecosta						67	
Monroe					1.25	75	.94
Ontonagon	4.00	12.00	4.00–12.00	5.00–20.00	4.125	50	2.06
Oscoda		20.00	20.00	30.00		50	
Ottawa	10.00	50.00	10.00	30.00	.86	50	.43
Presque Isle	5.00	50.00	18.00	18.00	2.75		
Washtenaw			35.00	35.00–40.00		80–90	
MINNESOTA.							
Brown	5.00–12.00	12.00	12.00	25.00–40.00		20–50	
Carlton	3.00	6.00	3.77	7.54		50	
Chisago	10.00	40.00	10.00	30.00	2.0	33⅓	.67
Cottonwood					2.0		
Crow Wing	5.00	6.00	5.00	7.00	1.6 4.0	60	.96 2.40

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TABLE B.—*Showing assessed valuation and true value of timber lands; also tax rate, fixed ratio of assessed to true value, and ratio of tax to true value, in certain States and counties, 1908*—Continued.

State and county.	Assessed valuation per acre.			4. True value per acre, representative tracts.	5. Total tax rate.	6. Fixed ratio of assessed to true value.	7. Ratio of tax to true value.
	1. Lowest.	2. Highest.	3. Representative tracts.				
MINNESOTA—cont'd.					*Per cent.*	*Per cent.*	*Per cent.*
Faribault						33⅓	
Kittson					2.96	50	1.48
Lac qui Parle			$12.00	$35.00		33⅓	
Lincoln					.84	33⅓	.28
Polk	(a)	(a)	6.00	100.00–200.00	4.2	25	1.05
Renville					2.1	40	.84
Rock					2.28	33⅓	.70
Roseau					4.0	33⅓	1.33
Stevens					2.8	33⅓	.93
Washington						(b)	
Watonwan					2.325	33⅓	.78
Yellow Medicine					2.066	33⅓	.69
NEW YORK.							
Cattaraugus	$5.00	$8.00	5.00	20.00–50.00	.225	50	.11
Cayuga				5.00–15.00	.5 1.5	75	.38 1.13
Chautauqua			30.00	60.00	.25	50	1.13
Chemung			6.00	10.00	.5	67	.34
Chenango					.586 1.94	75	.44 1.46
Lewis	2.00	10.00	2.00–10.00	3.00–15.00			
Orleans	.10	50.00	5.00–10.00	10.00–20.00	.7	67	.47
Otsego						70	
Putnam	50.00	75.00	25.00–50.00	5.00		67	
Yates						75	
NORTH CAROLINA.							
Ashe	1.00	5.00	5.00	15.00	1.00	33⅓	.33
Buncombe	2.50	15.00	4.00	4.00	1.3	100	1.30
Camden	1.50	3.00	3.00	6.00	1.16	50	.58
Caswell			6.00	15.00–20.00	1.00	33⅓	.33
Cherokee	4.00	12.00	4.00	6.00	.6	80	.48
Craven	4.00	8.00	8.00	25.00	.95	50–67	.48–.64
Forsyth	10.00	25.00	5.00–10.00	10.00–25.00	1.0	50–67	.50–.67
Granville	6.00	15.00	6.00	10.00	.8	60	.48
Greene	10.00	30.00	10.00	20.00		50	
Harnett	3.00	5.00	5.00	12.00–15.00	.8	33⅓–50	.27–.40
Hyde	30.00	60.00	20.00	50.00	.67	67	.45
Iredell	8.00	15.00	8.00–10.00	30.00–40.00	.67	25 95	.17 .64
Lenoir	1.00	5.00			.97	50–67	.49–.65
Macon	2.00	5.00	3.00	5.00	1.005	50	.50
Madison	3.00–6.00	20.00	5.00–15.00	10.00–30.00	1.037	50	.52
Montgomery	3.00	20.00	5.00	7.00	.87		
Randolph	3.00	20.00	5.00	15.00	.75		
Scotland				10.00	1.077		
Stokes	1.00	12.00	5.00	10.00		50	
Swain	5.00		5.00	12.00	.847		
Washington	5.00	10.00	6.00	10.00	.667	33	.22
Yadkin	7.00	15.00	8.00	15.00	.757	67	.51
PENNSYLVANIA.							
Adams	18.00	65.00	30.00	50.00	.4	67	.27
Blair	1.00	10.00	1.00–10.00	1.00–10.00	1.4	100	1.40
Carbon	30.00	125.00	10.00	30.00	1.0	33⅓	.33
Cumberland	5.00	75.00	1.00–50.00	1.00–75.00	1.0	80	.80
Jefferson	20.00	30.00	20.00–30.00	35.00–50.00	1.5 3.0	60	.90 1.80
Mercer	20.00	25.00	13.50	20.00	.8	75	.60
Mifflin	.50	2.00	1.00	2.00	1.57	50–67	.79–1.05
Pike	1.25	1.50	1.50		3.2		
Tioga	20.00	50.00			.6	67	.40
Venango	8.00	25.00	12.00–15.00	30.00–40.00	1.8		
Wayne	10.00		25.00	50.00	1.9	100	1.90

a Uniform assessment of $6 per acre.

b Less than 50 per cent.

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TABLE B.—*Showing assessed valuation and true value of timber lands; also tax rate, fixed ratio of assessed to true value, and ratio of tax to true value, in certain States and counties, 1908*—Continued.

State and county.	Assessed valuation per acre.			4. True value per acre, representative tracts.	5. Total tax rate.	6. Fixed ratio of assessed to true value.	7. Ratio of tax to true value.
	1. Lowest.	2. Highest.	3. Representative tracts.				
WASHINGTON.					*Per cent.*	*Per cent.*	*Per cent.*
Adams						60	
Chehalis	$5.00	$25.00	$12.50	$50.00	1.375	25	0.34
Island	7.00	40.00	7.00–40.00	20.00–100.00	3.0	40	1.20
Klickitat	[a] [b].50	[a] [c].50	6.00	10.00	2.2	60	1.32
Lewis	5.00	118.00	17.92	30.00	1.8 2.8	60	1.28 1.68
Skagit	[a].20	[a] 1.00				60	
Snohomish	[a].25				3.44	60	2.06
Stevens	1.25		3.00	10.00	3.5	40	1.80
Wahkiakum	[d].25	[d].80				25	
Yakima	.75	10.00	1.02	.75–2.50		60	
Pacific						30	

[a] Valuation of stumpage per m. [b] Plus land at $1.25. [c] Plus land at $2.50. [d] Per m.

V. MISCELLANEOUS EVIDENCE.

Some valuable evidence regarding the taxation of timber lands in Illinois has been prepared by a member of the Forest Service. Nine counties were studied, from which we obtain the following information: The average tax rates of the different counties range from 4 to 6 per cent, the average for all nine counties being 4.75 per cent. The practice of assessors in these counties is to value property very low. The assessed valuations run from one-fifth to one-eighth of the true value, or even less. For example, in one county improved lands were assessed on the average at $12 per acre and unimproved lands at $1.70. The market value of land in this county is estimated at from $40 to $60 per acre for improved lands, and from $5 to $15 for unimproved lands. In another county where improved lands were assessed at an average of $5.48 per acre, the true value was estimated at from $25 to $35. In another county the average assessed value of improved lands was $7.15, while the true value was estimated at about $35. The average assessed valuation of improved and unimproved land and the average tax rate for each county are shown in the following table:

Illinois, nine counties.

County.	Average assessed valuation of land.		Average tax-rate per-centage.
	Improved.	Unimproved.	
Alexander	$12.01	$1.71	5
Clinton	5.48	1.49	4
Fayette	7.15	3.49	4
Gallatin	7.10	1.72	5.75
Jackson	31.15	7.46	4
Johnson	5.50	1.55	4
Pope	6.34	2.64	6
Saline	5.41	1.20	6
Union	6.24	1.96	4

Combining these tax rates with the ratios of assessed valuation to true value, ranging from one-fifth to one-eighth, it would appear that lands are taxed on the whole somewhat less than 1 per cent of their true value, the general run being perhaps two-thirds of 1 per cent up to 1 per cent. These, of course, are only averages for the several counties. Extreme cases must undoubtedly be present, involving exceptionally high and exceptionally low taxation. It seems reasonable to conclude, however, that the majority of the

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lands in these counties are certainly not taxed more than 1 per cent of the true value.

The following quotation is of interest as showing the condition in Kentucky:[a] "The present valuation and rate of taxation on forest property seems fair and just and should remain as it is, as far as possible. When a rise in the valuation of other than forest property becomes necessary because of the greater development of the resources of the region, the valuation of forest property should be increased with great caution in order that the forest lands may be held to advantage for the production of future timber crops.

"In view of these facts, it is recommended that taxation of forest lands in this region be kept as nearly on its present basis as possible. If a readjustment of valuation should become necessary, care should be taken not to impose taxes that will prevent the profitable holding of forest lands by the private citizen for the production of timber."

A great deal of discussion of the taxation of timber lands has recently appeared in the forestry journals, the lumber trade journals, the publications of the United States Forest Service and of the several state foresters, and elsewhere. From these writings a few interesting examples of timber-land taxation may be culled. These sources are undoubtedly reliable, but naturally the cases given are mostly those of excessive taxation. A few cases may be worth while as showing, not the prevailing situation, but rather the extremes of excessive taxation found here and there. For example, "the forest commissioner of Pennsylvania reports that on one of the few pieces of virgin forest still standing in the State, containing a little less than 1,000 acres, the annual tax is $2.83 per acre. If the whole tract averages 20,000 feet per acre of white pine worth $10 a thousand on the stump—both estimates are high—the tax is 1.4 per cent of the value. The same authority * * * states that denuded lands are commonly assessed from 50 cents to $1.25 per acre, and that the usual levies amount to 25 to 30 mills. This means a yearly tax of 1¼ to 3¾ cents per acre. * * * The state forest reserve commission has bought at tax sales over 23,000 acres of such lands for the accrued taxes and costs. * * * The commissioner mentions one case where several parcels containing over 7,000 acres were bought in for a fraction over 8 cents per acre."[b]

It is stated that in Wisconsin the taxes on forest lands have been for years from 3 cents to 40 cents an acre without reference to changes in its condition or value, although more than one-third of the area of the State consists of cut-over lands too poor to be farmed and which may be bought for 25 cents to 50 cents per acre.[c]

"In North Carolina conditions are not much different. The common levy is 1 per cent on a 60 per cent valuation, or 6 mills on the estimated value. Where this value is justly assessed there can be no reasonable complaint, but there is much guessing, and in one county it is reported that land partly lumbered, or cut over as the forester advises, is taxed 25 per cent higher than virgin forest, on the ground that it is improved land. In other words, a penalty is imposed on conservative lumbering!"[d]

According to one of the Forest Service bulletins, cut-over lands in western Washington, which are valuable for nothing except the production of timber, are assessed at from $1 to $5 per acre, with a tax rate of from 15 to 30 mills on the dollar. These lands are estimated by the same authority as actually worth not more than $1 per acre. Large tracts of this land have been sold for 40 cents an acre.[e]

An interesting example of increased assessment comes from Oregon. One owner paid taxes amounting to $496.69 in 1907 and this year was called upon to pay $1,855.32, an increase of 274 per cent. Another tract was taxed $528.50 in 1907 and $1,804.54 in 1908. In another instance a timber claim which the owner was willing to sell for $2,400 was assessed for $4,700.[f]

Besides a mass of other similar evidence from the sources quoted above, the writer is in possession of a great deal of testimony from letters which he is not at present at liberty to make public. This testimony is in general accord with the evidence presented, and has been drawn upon in forming the conclu-

[a] Hand Book of the Kentucky State Department of Agriculture, 1906–7, p. 115.
[b] Gaskill, Proceedings of the Society of American Foresters, April, 1906, p. 119.
[c] Gaskill, Proc. Soc. Am. Foresters, April 1906, pp. 118–119. Fernow, Economics of Forestry, p. 252.
[d] Gaskill, Proc. Soc. Am. Foresters, April, 1906, p. 120.
[e] Forest Service Bulletin, No. 33, pp. 36–37.
[f] Langille, The Timberman, April, 1908, p. 42.

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sions expressed in the text. In New Jersey, for example, it is stated that timber lands are not compelled to bear a heavy burden of taxation at the present time, although here and there individual cases of excessive taxes are to be found. In general, timber lands are assessed far below their true value. In south New Jersey it is said that land bearing young pine is commonly taxed on a value not exceeding $1 per acre and that hard-wood forests in the northern part of the State, when newly cut over, are often assessed no higher than this. Similar testimony is at hand from Georgia, to the effect that the very low assessment of forest lands has thus far prevented excessive taxation on any large scale.

Chapter IV.

THE EFFECTS OF TAXATION ON THE FORESTS OF THE UNITED STATES.

Having shown, in a general way, what the actual burden of taxation on timber lands is at present, we must next inquire what effects taxation has had upon the forests of the country. It is commonly charged that taxation is responsible, (1) for a great deal of premature cutting of timber which would otherwise be left to grow to larger size; (2) for wasteful and destructive methods of cutting, commonly called "skinning;" (3) for the failure to hold lands once cut over for a second crop; and (4) for the general absence of the practice of forestry in America. It is important to know how far these charges are sustained by facts.

To a considerable extent the answer to this question may be inferred from the foregoing conclusions as to the burden of the general property tax on forests. There can be no doubt that in many of the cases where taxation has been excessive it has hastened the cutting of timber and led to wasteful skinning of the land, often destroying the chance of a valuable second growth, and sometimes leading to the abandonment of the land for delinquent taxes. On the other hand, in all those cases where the tax burden has been very small, taxation can obviously have had little influence on the management of the property.

The evidence on this question is from much the same sources as the evidence upon the burden of taxation discussed in Chapter III. This evidence, so far as it goes, shows that in some States, where taxation of timber lands and waste lands has been excessive, the taxation has had some influence in causing premature and wasteful cutting and in preventing the holding of cut-over lands for a second crop. Such evidence comes mainly from the States of Michigan, Wisconsin, Minnesota, Washington, and California. These are the States where we have seen some tendency toward excessive taxation of timber lands. The effects of taxation are more noticeable in preventing the reforesting of cut-over lands than in altering the management of mature or growing timber. These five are among the most important lumber-producing States of the country. They furnished one-fourth of the total cut in 1907. In them there is some evidence showing that considerable cut-over land has been abandoned because of the heavy taxation. This matter of abandoned lands is discussed more fully below.

On the other hand, there is evidence from a great many States tending to show that taxation has had no appreciable effect on the forests. These are States where the burden of taxation is so very light that it is seldom considered by timber owners and lumbermen.

In the general run of ordinary cases, as has been shown, the present burden of taxation can not be considered excessive. And in the general run of cases also there is little evidence to show that forests have been affected seriously by taxation. Indeed there is much positive evidence to the contrary. Among other sources, we have letters from nearly five hundred of the leading lumbermen of all parts of the country, written in reply to a schedule of inquiry sent out by the Forest Service. In answer to a question as to the influence of taxation on their lumbering operations, only 125 admit that it has had any appreciable effect. This includes a number of doubtful ones. The number that clearly testify to some undoubted influence on the part of taxation probably does not exceed 100. Of the replies, 234 state absolutely that taxation has had no influence, or very little. This testimony is discussed and the replies tabulated by States in the appendix to this chapter, from which it will be seen that the chief complaint of serious results of taxation comes from a small number of States, to some of which attention has already been called.[a] As said above, however, these States include some of the most important timber-producing States in the country.

It appears that in the general run of ordinary cases and in most parts of the country, at any rate outside of the five States named above, taxation has not had any great influence in causing the cutting of timber, and not very much influence in preventing reforesting. That the American forests have been cut off at a tremendous rate of late years, that the methods of cutting have often been wasteful and destructive of future growth, and that there is little tendency on the part of lumbermen to reforest cut-over lands are facts which need no demonstration. But that taxation has generally been an important influence in bringing about these results is an inference apparently not warranted by the facts. This is a phase of the problem which has been greatly exaggerated. The explanation probably lies in the fact that most of the discussion thus far has been on the part of those who were complaining against some particular cases of evil results from excessive taxation. That such cases undoubtedly exist in considerable number has already been shown. That they do not represent the prevailing situation has also been shown. The recent heavy and wasteful cutting of our forests has been due to various economic influences, among which taxation has played a comparatively small rôle.

A good deal of cut-over land has been abandoned for taxes in certain parts of the country, particularly in the States in the region of the Great Lakes and on the Pacific coast. California probably has about a million acres of such delinquent-tax lands. Michigan also has about a million acres. Wisconsin has a large area. In some cases this has been due, in part at least, to excessive taxation. For example, in western Washington cut-over lands are assessed at from $1 to $5 per acre, although according to the estimate of a Forest Service expert the land is not worth more than $1 per acre, and large tracts have actually been sold for 40 cents an acre.[b] But while this state of affairs exists in some States, and is in some cases due to excessive taxation, still throughout the country as a whole there is very little land abandoned for taxes, and in the great majority of the States the matter of abandoned lands is negligible.

[a] See Appendix to Chapter IV, p. 608.
[b] Forest Service Bulletin No. 33, pp. 36, 37, 45.

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As evidence on this point, it is significant that out of nearly five hundred letters from lumbermen all over the country only eight stated that taxation had led them to abandon their lands.[a] Further evidence on this subject comes from letters received from local tax assessors and others in 177 counties of Alabama, California, Iowa, Louisiana, Maryland, Michigan, Minnesota, New York, North Carolina, Pennsylvania, and Washington. Out of these 177 counties only 25 report any appreciable amount of abandoned lands; and, so far as these replies go, they seem to show that in the great majority of counties practically no land is being sold or abandoned for taxes, and that in only a few counties is the question of delinquent tax lands a matter of any importance.[b]

Forestry is very little practiced in America to-day, but that this state of affairs has been due in any great measure to taxation is denied by the evidence. The lumbermen, as a rule, are not thinking much about forestry. There are other factors in the forestry problem of far greater weight than taxation, and the general practice of forestry will not be brought about by amendments to the tax laws. This conclusion also is supported by the great majority of the letters received from lumbermen all over the country. The majority either ignore the question altogether or state that a change in taxation would make no difference in the management of their lands. And of the others, very many admit only a problematical effect, or an effect in some cases. In answer to the specific question, whether reduced taxes would lead to planting or holding cut-over lands for second growth, the number of affirmative replies is still smaller.[c]

We conclude, then, that while in some cases, and in certain parts of the country, forests have been excessively taxed with more or less serious results, as a general rule taxation has not, up to the present time, been responsible for any widespread disastrous results on the forests of the country.

APPENDIX.

SOME EVIDENCE REGARDING THE EFFECTS OF TAXATION ON THE FORESTS OF THE UNITED STATES.

1. LETTERS FROM LUMBERMEN.

The following questions, among others, were sent to representative lumbermen all over the country by the Forest Service in the summer of 1908:

1. In what way, if any, have your lumbering operations been influenced by the rate of taxation applied to your holdings?

2. Would a reduced tax lead you to adopt different methods so as to preserve young growth or to leave seed trees in order to provide for a future crop, and for the protection of cut-over land from fire?

a. Would it lead you to plant such of your holdings as have been cut over when planting is necessary?

b. Would it influence you not to abandon cut-over lands? If so, what would the ratio between the present tax and the reduced tax have to be?

About 500 answers were received which give some valuable testimony as to the effects of taxation on the forests of the country. Incidentally they throw

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[a] See above; also Appendix to Chapter IV, p. 609.

[b] The full replies to this question are given by States and discussed, together with some other evidence on the subject of abandoned tax lands, in the Appendix to Chapter IV, p. 611.

[c] The evidence is presented and discussed in the Appendix to Chapter IV, pp. 611.

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some light on the actual burden of taxation on timber lands. In some cases the replies are not very clear, and it has required the exercise of some judgment to tabulate them. The doubtful cases, however, are not numerous enough to affect the conclusions to be drawn from the answers.

The answers to the first question may be classified as follows:

Answers to question 1.

1. Number of letters received	484
2. No information on this question	117
3. No influence, or very little	234
4. Probable future influence	8
5. Some influence	125
a. Character not specified	1
b. Hastens cutting	117
c. Leads to abandoning land	8

The cases in which taxation is said to have exercised some influence include a number of rather vague replies. Probably the number that clearly testify to some real influence would not be over 100. These replies are significant as showing how little influence taxation has really had upon the management of forest properties.

The replies give additional information of interest when they are classified by States, as is done in the following table, though the number of cases in many individual States is too small to allow the drawing of any positive conclusions:

Answers to question 1, by States.

State.	1. Number of letters received.	2. No information.	3. No influence, or very little.	4. Probable future influence.	5. Some influence.			
					Total.	*a*. Character not specified.	*b*. Hastens cutting.	*c*. Leads to abandoning land.
Alabama	6	2	3		1		1	
Arkansas	21	6	7	1	7		7	
California	10	1	9		0			
Connecticut	13	5	7		1		1	
Delaware	1	0	1		0			
Florida	11	2	5		4		4	
Georgia	10	5	5		0			
Idaho	6	0	4	1	1		1	
Indiana	1	1	0		0			
Kentucky	8	3	4		1		1	
Louisiana	33	4	14		15		15	
Maine	9	6	2		1		1	
Maryland	4	1	2		1			1
Massachusetts	30	6	17		7		5	2
Michigan	17	1	9		7		7	
Minnesota	8	2	1		5		5	
Mississippi	18	3	11	1	3		3	
Missouri	6	1	3		2		2	
Montana	10	1	6		3		3	
New Hampshire	9	3	3		3		3	
New Jersey	2	2	0		0			
New York	34	12	15		7		5	3
North Carolina	17	5	10		2		2	
Ohio	1	0	1		0			
Oklahoma	2	1	1		0			
Oregon	34	5	23	2	4	1	3	
Pennsylvania	8	1	2		5		5	
Rhode Island	1	0	1		0			
South Carolina	10	2	8		0			
Tennessee	9	3	6		0			
Texas	19	3	10		6		6	
Vermont	7	2	2		3		3	
Virginia	12	4	7		1	1		
Washington	55	16	21	3	15		13	2
West Virginia	16	4	8		4		4	
Wisconsin	34	6	9		19		19	
All others [a]	5	1	4		0			
Total [b]	497	120	242	8	128	2	119	8

[a] Cases where the State was not indicated.

[b] The totals here exceed those in the summarized table above, for the reason that replies from companies operating in more than one State have been counted under each State.

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The replies to questions 2, 2*a*, and 2*b* show the following results:

Answers to question 2.

1. Number of letters received	484
2. No information on this question	100
3. No, or doubtful	166
4. Yes, or probably, or in some cases	218

Answers to question 2a.

1. Number of letters received	484
2. No information on this question	173
3. No, or doubtful	182
4. Yes, or possibly, or would consider it	129

Answers to question 2b.

1. Number of letters received	484
2. No information on this question	184
3. No	123
4. Yes	177

Here also, as in tabulating the answers to the first question, a good many rather vague statements have been counted as affirmative replies. The number of clear and positive affirmatives would be considerably below the figures given above.

II. LAND ABANDONED ON ACCOUNT OF TAXES.

Some interesting evidence on the subject of delinquent-tax lands has been obtained from letters of local assessors, town and county officers, and others, received in reply to a schedule of questions sent out by the Forest Service. One of these questions was, "To what extent has cut-over land in your locality reverted to the county or State or been sold because of nonpayment of taxes?" Answers to the general schedule were received from 175 counties of Alabama, California, Iowa, Louisiana, Maryland, Michigan, Minnesota, New York, North Carolina, Pennsylvania, and Washington. In answer to the question about delinquent-tax lands, 73 counties report "none;" 37, "very little;" 2, "none lately;" 38 give no answer at all; and 25 report some abandoned lands together with some information as to their extent. The information contained in these last 25 replies is as follows:

In Alabama, one county reports one-fourth of 1 per cent, another 1 per cent, and the third, "some." In California, one county reports one-twentieth, and one, 23,638 acres. Four counties in Louisiana report, respectively, "some, but soon redeemed," 15 per cent, 360, and one-tenth. Six counties in Michigan answer, respectively, 5 per cent, less than 1 per cent, 1,009, 10 per cent, 10 per cent, and 300. One county in Minnesota reports 300 acres. Two counties in New York report, respectively, 10 per cent, and 6 per cent. In North Carolina, one county reports 10 per cent and another 5 per cent. In Pennsylvania 5 counties report, respectively, "some," "great extent," "300 acres every two years," 1,000 acres, and "nearly all." The exact meaning of these replies is not always very clear.

These replies, so far as they go, seem to show that in the great majority of counties practically no land is being sold or abandoned on account of taxes, and that in only a few of the counties is the question of delinquent-tax lands a matter of any importance. The returns, summarized by States, are given in the following table:

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Lands abandoned on account of taxes.

State.	Number of counties.	None.	Very little.	None lately.	No answer.	Some; extent specified.
Alabama	21	9	6	1	2	3
California	19	3	6	1	7	2
Iowa	20	15	1	.....	4	.....
Louisiana	24	14	3	.....	3	4
Maryland	1	1	.....	.....	.....	.....
Michigan	18	7	2	.....	3	6
Minnesota	18	3	3	.....	11	1
New York	10	3	4	.....	1	2
North Carolina	22	11	7	.....	2	2
Pennsylvania	11	3	2	.....	1	5
Washington	11	4	3	.....	4	.....
Total	175	73	37	2	38	25

The following statement, taken from Forest Service Bulletin No. 33, page 37, gives some additional evidence. The reports were furnished by the assessors of some of the timbered counties of the State of Washington, and state the amount of cut-over land which has been abandoned:

Abandoned lands in Washington.—Chehalis County, 71 per cent; Clallam County, none nominally abandoned, much delinquent; Clarke County, none; Jefferson County, 20 per cent; King County, none; Pacific County, none at present, indications that large amount will be abandoned; Pierce County, information wanting; Skagit County, very little; Whatcom County, 20 per cent.

CHAPTER V.

THE REAL ECONOMIC PROBLEM OF FOREST TAXATION.

It does not follow from the conclusion reached in the last chapter that the problem of forest taxation is of no importance or of academic interest only. The problem is, in fact, of the utmost importance, and is moreover decidedly practical. But its practical bearing is on the future of our forests rather than on their past. The methods of handling the forests of the United States which have prevailed in the past can not continue much longer. This statement is supported by such an overwhelming mass of testimony on the part of the forestry experts that we may accept it without further discussion. On the same authority we accept the proposition that the preservation of our forests is a matter of urgent importance, and that disastrous consequences are bound to follow their destruction. The practice of forestry, then, must come some time, and its speedy coming is a thing greatly to be desired; and whenever we are ready to seriously undertake it, we will find our present methods of taxation a heavy handicap. It is then that taxation will appear as a vitally important element in the situation.

It can be shown theoretically that the general property tax, strictly enforced in accordance with the letter of the law, must inevitably lead to excessive taxation in all cases of invested wealth which is appreciating in value. Suppose a man invests $10,000 in a perpetual annuity at 5 per cent, yielding an annual income of $500. Suppose an annual property tax of 1 per cent is imposed. The tax will take $100, or 20 per cent of the income each year. Suppose now that

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another man, having $10,000, puts it in trust for fourteen years, after which time, the principal having doubled, he invests it in a perpetual annuity of $1,000 a year. Under the property tax he is taxed $100 the first year, but the second year, his capital having increased to $10,500, he pays a tax of $105. His tax increases each year till the fourteenth, after which it is $200 a year. The present value of all the taxes paid by the first man is $2,000, or 20 per cent of his capital. The present value of all the taxes paid by the second man is $3,428, or 34 per cent of his capital. That is, the man who does not use up his income, but invests it, is punished by an excessive tax.[a]

Now, the business of forestry is apt to be like the investment of the second man. The annual growth of the trees, instead of being taken each year as income, is left to increase the capital, till many years later when the timber is cut and the income begins to accrue. A property tax, strictly enforced, must inevitably place an excessive burden upon forests as compared with the ordinary investments yielding a regular annual income. It might easily take away from one-third to one-half of the entire net income, and very much more under certain conditions. This assumes, what the law clearly requires, that the forest be taxed each year on its true value, land and timber together.[b] Forestry should not be subjected to such an unjust burden.

It may be objected that as a matter of fact forests are not taxed on anywhere near their true value, and this practice should be recognized. But this does not relieve the situation much. Probably nothing more effectually discourages investment than uncertainty as to future costs. And whatever may be said of the present system of taxation, there can be no question of its arbitrariness and uncertainty. If to all the other risks of forestry we add uncertainty as to what the taxes are going to be, we can not blame investors for some hesitation in embarking on an enterprise which may have to pay taxes fifty years before the returns come in. And more than this; the investor can not safely base his calculations on the continuance of the present lenient administration of the property tax. As has been shown, the tendency to-day is toward a stricter enforcement of the law and a heavier burden of taxation.

There is a good deal of evidence from a variety of sources tending to show that in the few cases where forestry has already been seriously considered, the matter of taxation has been one of the most important items in the calculation and in many cases has been an insuperable obstacle.

The problem of forest taxation is, then, an important one, and a very practical one. It is safe to say that we can hardly hope to see the general practice of forestry by private owners until our methods of taxation are made more scientifically equitable and certain. The importance of this problem will necessarily increase as time goes on until it is properly solved. The subject, therefore, deserves the most careful and thorough investigation.

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[a] For a discussion of the economic principle here involved, cf. Fisher, "The nature of capital and income," Chapter XIV; especially pp. 249–255.

[b] For a further discussion of this matter based on mathematical examples, see Appendix to Chapter V, p. 613.

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APPENDIX.

MATHEMATICAL ILLUSTRATION OF THE POSSIBLE BURDEN ON FORESTRY OF THE GENERAL PROPERTY TAX.

This appendix presents mathematical examples illustrating the statement of the text that the general property tax, strictly enforced according to the letter of the law, might easily take away a very large part of the income of the business of forestry. In these examples, the figures for cost of planting and value of standing timber are taken from an example worked out by the New Hampshire forestry commission.[a] The figures are for white pine in the State of New Hampshire. In all cases the rate of interest is assumed as 5 per cent.[b] The figures are for 1 acre of land.

Table A gives the following facts for five-year periods from the twentieth year to the seventieth: (1) The cost of planting, with accrued interest to the several dates; (2) the value of the standing timber at the several dates; (3) the net income of the forests, which is the difference between the value of the trees and the cost of planting, with interest to date; (4) the present expectation value of the forest if cut, respectively, at the three years which give the largest value; (5) the amount of the taxes with accrued interest to date—the taxes on the land and trees are given separately, the trees being exempt from taxation for the first 20 years; (6) the ratio of the taxes to the net income, given as a percentage; (7) the net income less taxes; and (8) the expectation value based on net income after deducting taxes. The tax rate is assumed at 1 per cent. It is assumed that the land is taxed on its full value—that is, on its present expectation value as a forest. In this example the most profitable year for cutting is the fiftieth. If cut in that year the present expectation value is $10.36. We have assumed that the land is taxed on a valuation of $10.

Some interesting results are evident from this table. In the first place, the taxes exceed the net income yearly up to the fortieth year and after the seventieth year. In the fiftieth year the ratio of taxes to net income is the smallest, being 39 per cent, and this year is still the most profitable cutting year, although the net income less taxes would be slightly greater if it were cut in the fifty-fifth year. Of course, the most important purpose of this table is to show that taxation under the assumed conditions will take 39 per cent of the total net income.

In order to show that the burden of taxation will still be very heavy, even though the land be valued considerably below its expectation value, Table B is presented. The figures in this table are the same as in Table A, with the exception that the land is assessed at $5. This is the value assumed by the New Hampshire forestry commission in their examples. In this case the taxes in the fiftieth year amount to 29 per cent of the net income, still a very high tax, although the land is assessed at only half of its true expectation value.

In Table C the circumstances are altered by assuming that the forest grows up without any cost of planting. Here also the most profitable cutting year is the fiftieth. Assuming that the forest is cut in this year the expectation value is $18, and we assume that the land is taxed on that value. The result shows a tax in the fiftieth year of 31 per cent of the net income.

In all these examples we have assumed a tax rate of 1 per cent, which is, of course, very low as compared with present prevailing rates, which are generally somewhere in the neighborhood of 2 per cent. One per cent was taken as representing roughly the percentage of present taxes to the true value of property. Since the total tax varies directly with the rate it is a simple matter to alter the figures in any of these examples to correspond to any given tax rate. As a single illustration of this Table D is presented, showing the result of a tax rate of 2 per cent under the conditions given in Table A. Obviously the taxes, and also the percentage of taxes to net income, are exactly doubled. The best that the forest owner can do is to cut in the fiftieth year and hand over 78 per cent of his net income in the form of taxes.

These examples, of course, show nothing as to the burden of taxation which may be expected under any particular conditions. They do show, however, the very heavy burden which may easily result from the general property tax under ordinary conditions.

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[a] Report of the New Hampshire Forestry Commission, 1905–6, p. 246.

[b] The question of the proper rate of interest for forestry investments is discussed in the Appendix to Chapter VI, p. 618, and in Chapter VI.

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Examples of taxation.

TABLE A.

Year.	Cost of planting, with interest.	Value of timber.	Net income.	Expectation value.	Taxes on land value, $10.	Taxes on trees.	Total taxes.	Ratio of taxes to net income, per cent.	Net income, less taxes.	Expectation value, taxes deducted.
1	$7.00	.....	.....	.....	$0.10	.....	$0.10	.....	.....	.....
20	18.57	$4.41	−$14.16	.....	3.30	.....	3.30	.....	−$17.46	.....
25	23.70	9.44	− 14.26	.....	4.78	$0.22	5.00	.....	− 19.26	.....
30	30.25	19.98	− 10.27	.....	6.64	.78	7.42	.....	− 17.69	.....
35	38.61	41.52	2.91	.....	9.04	2.11	11.15	383	− 8.24	.....
40	49.28	82.50	33.22	.....	12.08	5.02	17.10	51	16.12	.....
45	62.90	133.66	70.76	$8.86	15.98	11.01	26.99	38	43.77	$5.48
50	80.27	189.00	108.73	10.36	20.94	21.46	42.40	39	66.33	6.32
55	102.45	238.28	135.83	9.99	27.28	37.83	65.11	48	70.72	5.20
60	130.75	286.77	156.02	.....	35.36	61.39	96.75	62	59.27	.....
65	166.88	334.43	167.55	.....	45.68	94.20	139.88	83	27.67	.....
70	212.98	385.02	172.04	.....	58.86	138.68	197.54	115	− 25.50	.....

TABLE B.

Year.	Net income.	Taxes on land value, $5.	Taxes on trees.	Total taxes.	Ratio of taxes to net income, per cent.	Net income, less taxes.	Expectation value, taxes deducted.
1	.....	$0.05	.....	$0.05	.....	.....	.....
20	−$14.16	1.65	.....	1.65	.....	−$15.81	.....
25	− 14.26	2.39	$0.22	2.61	.....	− 16.87	.....
30	− 10.27	3.32	.78	4.10	.....	− 14.37	.....
35	2.91	4.52	2.11	6.63	228	− 3.72	.....
40	33.22	6.04	5.02	11.06	33	22.16	.....
45	70.76	7.99	11.01	19.00	27	51.76	$6.48
50	108.73	10.47	21.46	31.93	29	76.80	7.31
55	135.83	13.64	37.83	51.47	38	84.36	6.20
60	156.02	17.68	61.39	79.07	51	76.95	.....
65	167.55	22.84	94.20	117.04	70	50.51	.....
70	172.04	29.43	138.68	168.11	98	3.93	.....

TABLE C.

Year.	Value of timber, no costs.	Expectation value.	Taxes on land value, $18.	Taxes on trees.	Total taxes.	Ratio of taxes to income, per cent.	Net income, less taxes.	Expectation value, taxes deducted.
1	.....	.....	$0.18	.....	$0.18	.....	.....	.....
20	$4.41	.....	5.94	.....	5.94	135	−$1.53	.....
25	9.44	.....	8.60	$0.22	8.82	93	.62	.....
30	19.98	.....	11.95	.78	12.73	64	7.25	.....
35	41.52	.....	16.27	2.11	18.38	44	23.14	.....
40	82.50	.....	21.74	5.02	26.76	32	55.74	.....
45	133.66	$16.73	28.76	11.01	39.77	30	93.89	$11.75
50	189.00	18.00	37.69	21.46	59.15	31	129.85	12.37
55	238.28	17.52	49.10	37.83	86.93	36	151.35	11.13
60	286.77	.....	63.65	61.39	125.04	44	161.73	.....
65	334.43	.....	82.22	94.20	176.42	53	158.01	.....
70	385.02	.....	105.95	138.68	244.63	64	140.39	.....

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Examples of taxation—Continued.

TABLE D.

Year.	Net income.	Total taxes.	Ratio of taxes to net income, per cent.	Net income, less taxes.	Expectation value, taxes deducted.
1		$0.20			
20	−$14.16	6.60		−$20.76	
25	− 14.26	10.00		− 24.26	
30	− 10.27	14.84		− 25.11	
35	2.91	22.30	766	− 19.39	
40	33.22	34.20	103	− .98	
45	70.76	53.98	76	16.78	$2.10
50	108.73	84.80	78	23.93	2.28
55	135.83	130.22	96	5.61	.42
60	156.02	193.50	124	− 37.48	
65	167.55	279.76	167	−112.21	
70	172.04	395.08	230	−223.04	

CHAPTER VI.

THE PRINCIPLES OF SCIENTIFIC FOREST TAXATION.

The foregoing discussion has shown the fundamental weakness of the present methods of taxing timber lands and the necessity of adopting some scientific system which will secure both equity and certainty. It is now necessary to inquire into the fundamental principles which must be the basis of any correct method of taxing timber lands.

We may assume, without much danger of controversy, that taxation should be based on income or earning power. The tax on income may be collected at the time the income accrues, or it may be in the form of an annual tax on the capital value of the income. If the rates of the income tax and the capital tax bear the proper relation to each other, those two ways of applying the tax produce identical results. For example, if the interest rate is 5 per cent, an income tax of 20 per cent is equivalent to an annual capital tax of 1 per cent, provided the business taxed is earning a regular annual income. In general the rate of the capital tax is equal to the rate of the income tax multiplied by the rate of interest.

In the case of forests, the tax based on income may be applied in either of two ways, (1) as a tax on the yield whenever any timber is cut, or (2) as an annual tax on the present capital value of the forest, based on all its expected future incomes and expenditures, what the foresters call "expectation value." To illustrate by a single example, suppose that a forest is so managed as to yield a net income of $150 sixty years from to-day, and again every sixty years thereafter, without any cost for planting. If interest is at 5 per cent, a simple calculation will show that the present expectation value of the forest is $8.47. Suppose it is desired to tax this forest at the rate of 20 per cent of its net income. This may be accomplished either by a tax of 20 per cent of the net yield whenever it occurs, or by an annual tax of 1 per cent of the expectation value. The first would mean a tax of $30 paid every sixty years when the timber was cut. The second would mean a tax of 8½ cents paid every year. The present value of these two taxes—that is, $30 paid sixty years from date and every sixty years thereafter, and 8½ cents paid every year, beginning at once—is exactly the same.

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The above is an example of a forest managed to produce a sustained periodic yield; that is, the timber is cut at long intervals, the forest being renewed after each cutting so as to produce about the same yield after each rotation period forever. Forests may also be managed so as to produce a sustained annual yield. In this case, timber is cut annually, about the same amount each year, and the forest is maintained without deterioration forever. And finally, forests may not be managed according to any system of forestry, the yield being purely irregular.

Obviously the tax on yield when cut may be applied to any forest, whatever the system of management, or even where no systematic management is employed. This method simply takes a certain part of the yield whenever any timber is cut. On the other hand, the tax on expectation value is more complicated. It requires the calculation of present value based on all future expected incomes and expenses. And in the case of the forest with irregular yield it is impossible to apply this method at all, for there is no way of calculating the expectation value.[a]

A matter of the utmost importance in the case of the tax on expectation value is the rate of interest at which the calculation is made. That a good deal depends on what rate is selected may be realized from the single fact that if in the above example 4 per cent had been used instead of 5, the annual tax would have been 16 cents instead of 8½ cents. A change of a single unit in the rate of interest may double or even treble the amount of the tax. Evidently the rate of interest is the crux of the whole theory of the tax on expectation value. This subject has never received the thorough investigation which its importance deserves. A short discussion is given in the appendix to this chapter. The following very brief suggestions are offered here.

Writers of the technical works on forestry are inclined to capitalize forest investments at very low rates of interest, 2½ or 3 per cent being usually adopted. The writer is convinced that these rates are too low, at least for American conditions. To mention only two reasons for this belief: In the first place, the risk of fire is so great that no insurance company will accept it. In the second place, forestry is peculiar in the long interval of time which must generally elapse before the investment begins to yield an income. It is a well-known psychological fact that such an income will be discounted at a higher rate of interest than those whose enjoyment is less remote.

Without mentioning other reasons for a high rate, the writer is convinced that, as compared with ordinary investments, forest investments must be capitalized at a relatively high rate of interest. Five per cent is certainly not too high. It is very probably too low. This question must be carefully considered in applying a tax on expectation value.

The selection of the rate of the forest tax, whether a tax on yield when cut or on expectation value, is simple theoretically. If it is desired to place the same relative burden on forests as on other kinds of wealth, the rate on expectation value should be the same as the actual rate of the general property tax on true value;[a] the rate on yield when cut is the quotient of the rate of the property tax divided

[a] For a more extended discussion of the theory of forest taxation, with numerous mathematical examples, see Appendix to Chapter VI, p. 618.

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by the rate of interest. If it is desired to offer special inducements to forestry by a lower burden of taxation, the above rates may be reduced in any desired degree.

In order to avoid uncertainty and arbitrary taxation, the rate of the forest tax should be determined by a state officer or board, the rate to apply in all parts of the State; or the State may merely establish a maximum rate, leaving to any town the liberty to levy a lower rate if desired.

It has been shown that in general the scientific principles of forest taxation may be applied either as a tax on yield when cut, or as a tax on the capital value of the forest. It now becomes necessary to weigh the relative merits of these two methods of taxation with particular reference to American conditions.

No sooner is the question raised than the answer forces itself upon us that the tax on expectation value is not capable of general application in the United States. This method depends on the general practice of forestry, whereas in America the practice of forestry is the rare exception outside of the public reserves. This method requires the existence of accurate yield tables for the various species of trees and for different parts of the country. Only the smallest beginning has yet been made toward the construction of such tables for America. This method can not be applied to forests producing an irregular yield. Yet nearly all the forests in the United States are of this class.

These considerations alone show the impossibility of applying the tax on expectation value in America at the present time and for a long time to come. On the other hand, there are some positive considerations in favor of the tax on yield which are of the greatest importance. In the first place, the tax on yield avoids the whole problem of the rate of interest, which has been shown to be at once the most important and the most difficult theoretical factor in the tax on expectation value. When a forest is taxed on its yield, the value of the yield and the value of the tax will bear the same relation to each other, no matter what the rate of interest, since both are necessarily discounted at the same rate. For example, if a forest yields $150 net income every sixty years and is taxed 20 per cent of the yield, or $30 every sixty years, the present value of the tax of $30 will always be one-fifth of the present value of the yield of $150, no matter what rate is used in discounting. The importance of this argument in favor of the tax on yield can hardly be exaggerated.

Again, the use of the tax on yield relieves us of the necessity of estimating the future prices of timber. All calculations of expectation value are rendered more or less untrustworthy by the great uncertainty as to future prices of timber. All the estimates on this subject must be a matter of more or less skillful guesswork. The objection to a tax based on such calculations is obvious. On the other hand, future prices of timber are a matter of indifference as regards the principles of the tax on yield. Since the tax is a certain part of the yield, changes in price affect both the yield and the tax in the same way. Here also is a most weighty argument in favor of the tax on yield.

[a] For example, if the rate of the general property tax is 2 per cent, and property is usually assessed at a fixed ratio of 50 per cent of its true value, the rate of the tax on true value is 1 per cent.

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Similarly, by basing the tax on yield, we eliminate the element of risk from the tax problem. The danger of loss by fire, etc., is so great that forestry investments are at best decidedly uncertain. This risk, as is shown above, should be taken into account in determining the rate of interest. But no one can estimate the degree of risk with any approach to accuracy, and no allowance in the rate of interest can prevent serious injustice being done in individual cases. An owner may have been paying taxes on his forest for fifty years, only to see the yield at last wiped out by a destructive fire. Moreover, such a system would act as a deterrent influence against forestry investments. When the annual taxes to be paid are a sure thing, while the yield to be obtained after fifty years is very uncertain, we can not blame the investor for hesitating. All this is avoided by the tax on yield. Forest investments will still be subject to risk, but the risk will not be complicated by taxation. Taxes are paid on the yield, and if the yield is destroyed by fire the taxes are thereby automatically remitted.

Another argument, though of less importance, is worthy of mention here. In certain cases the tax on expectation value might lead to premature cutting. If an owner became financially embarrassed, so that the payment of his annual tax became a matter of difficulty, he might be led to cut immature timber to get money to pay his taxes. The tax on yield would not have this influence.

We conclude, therefore, that the superiority of the tax based on yield when cut is demonstrated beyond question. We may therefore dismiss the tax on expectation value, and confine the discussion of practical applications and administrative problems to the tax based on yield when cut.

APPENDIX.

THE THEORY OF FOREST TAXATION.

I. THE THEORY OF FORESTRY AND FOREST TAXATION.

Assuming that taxation should be based on income or earning power, any given tax on income-producing wealth may be levied either as a tax on the net income whenever it accrues, or as an annual tax on the capital value of all the expected future net incomes.

In order to have a sound theoretical basis for the study of forest taxation, it will be necessary to inquire into the economic character of the business of forestry. Assuming that some regular system of forest management is in operation, the receipts and expenditures of a forest occur at different times, according to the way in which the forest is managed. In order to express the problem in mathematical terms, the following notation is used:[a]

Let p = the rate of interest.

Let r = the number of years in the rotation period; i. e., the number of years between successive major cuttings.

Let Y_r = the value less cost of harvesting of each final or major yield, realized every r years.

Let T_a, T_b . . . T_q = the value less cost of harvesting of the intermediate yields from thinnings, etc., occuring in the years a, b, . . . q. Each of these thinnings occurs during every rotation, that is, every r years. Thus the first thinning T_a occurs after a years, again after $a + r$ years, again after $a + 2r$ years, etc.

Let m = the annual value of any annually recurring incidental revenue, as, for example, grazing fees, rent of the forest for hunting, etc.

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[a] Cf. Schlich, Manual of Forestry, Vol. III, third edition, pp. 122–126; Fernow, Economics of Forestry, pp. 215–216; etc.

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Let M = the capitalized value of the annual incidental revenue; that is, $M = \frac{m}{.0p}$.

The quantity m (or M) may generally be disregarded, or may be assumed to have been deducted from the annually recurring expenses e (or E).

Let c = the cost of formation (planting, etc.) which has to be incurred at the beginning of each rotation, occurring, therefore, every r years. We may assume that this cost is the same at the beginning of each rotation.

Let e = the annual value of all annually recurring expenses, as cost of administration, etc. For our problem, e does not include taxes.

Let E = the capitalized value of the annual expenses; that is, $E = \frac{e}{.0p}$.

Let S_e = the expectation value ("soil expectancy value") of the forest; that is, "the sum of the present values of all returns expected from the soil in the course of time, less the present value of all expenses which must be incurred to obtain these returns,"[a] at the beginning of the rotation period, or just after one of the cuttings, Y_r;

The expectation value, or present capitalized value, of a forest in which the above items of revenue and expenditure occur is then represented by the following formula:

$$S_e = \frac{Y_r + T_a\,(1.0p)^{r-a} + \ldots\ldots + T_q\,(1.0p)^{r-q} - c(1.0p)^r}{1.0p^r - 1} - E.^b$$

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[a] Schlich, p. 122.

[b] For those not familiar with the mathematics involved in the above formula, the following explanation may be of service: All the items of revenue and expense are reduced to their present value at the beginning of the rotation period; i. e., just after a final harvest has been cut and before the planting for the next harvest has been made. The final income Y_r will occur after a period of r years, and again every r years forever. The present value of such an income is, according to a well-known mathematical formula, $\frac{Y_r}{1.0p^r - 1}$. The first intermediate revenue appears in the year a, and is represented by T_a. In the year r it will amount with accumulated interest to $T_a(1.0p)^{r-a}$. The same revenue will appear again after $a+r$ years, and so on every r years forever. The present value of such an income is $\frac{T_a(1.0p)^{r-a}}{1.0p^r - 1}$. Likewise the value of the next thinning, coming in year b and every r years thereafter, is $\frac{T_b(1.0p)^{r-b}}{1.0p^r - 1}$; and so on to the last thinning before the final harvest, T_q, whose present value is $\frac{T_q(1.0p)^{r-q}}{1.0p^r - 1}$. The cost of planting, etc., is c. With accumulated interest this cost will amount, in the year r, to $c(1.0p)^r$. It will occur again in the year r and every r years thereafter forever. The present value of all these expenses is $\frac{c(1.0p)^r}{1.0p^r - 1}$. The regular annual expenses e occur every year forever. Their present value is therefore $\frac{e}{.0p} = E$. The sum of the present value of all these items of revenue less the present values of all the items of expense gives the present value of the forest or its expectation value. Thus:

$$S_e = \frac{Y_r}{1.0p^r - 1} + \frac{T_a(1.0p)^{r-a}}{1.0p^r - 1} + \ldots\ldots + \frac{T_q(1.0p)^{r-q}}{1.0p^r - 1} - \frac{c(1.0p)^r}{1.0p^r - 1} - E.$$

This expression reduces to the formula of the text,

$$S_e = \frac{Y_r + T_a(1.0p)^{r-a} + \ldots\ldots + T_q(1.0p)^{r-q} - c(1.0p)^r}{1.0p^r - 1} - E.$$

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This is the general formula representing all possible systems of forest management. When applied to particular kinds of management the formula may be changed by the omission of certain of its terms. Where no regular system of forestry is practiced, the formula obviously has no application. For the sake of clearness we may classify forests according to their management as follows:

I. Producing a sustained annual yield.
II. Producing a sustained periodic yield,
  1. Clear cutting,
    a. Reproduced by planting.
    b. With natural reproduction.
  2. Selection cutting.
III. Producing an irregular yield (where systematic forestry is not practiced).

I. First, and simplest of all, we have the case of the forest managed so as to produce a sustained annual yield.[a] In this case a regular income is obtained each year, presumably forever. Here r is 1; there is no cost of planting, and hence c is 0; T and A are disregarded, being merged in Y; and we have simply an annual net income representing the difference between the annual yield from all sources and the annual expenses of all kinds. Let this annual net yield=Y. Then the capital value of the forest is obtained from the equation,

$$S_e = \frac{Y}{.0p}.$$

For example, suppose a forest produces an annual net income of 50 cents an acre.[b] In this and the following examples we assume the rate of interest is 5 per cent. Then $p=5$; $v=0.50$; $S_e=\frac{0.50}{0.05}=10$. That is, we have a forest yielding a net annual income of $0.50 per acre and whose capital value is therefore $10 per acre.[c] This case is like the ordinary business investment.

II. The forest which produces a sustained periodic yield resembles the case just described in that the yield is sustained and fairly regular. It differs in that the principal yield occurs not every year but at longer intervals. The timber may be removed either by clear cutting or by selection cutting. In the first case the timber is practically all removed, and the interval which must elapse before another cutting is the time necessary for the trees to grow to the most profitable cutting age. This case is subdivided according as the forest is renewed after cutting by planting or by natural reproduction.

1, *a*. When a forest is made to produce a sustained periodic yield by clear cutting, reproduced by planting, we have the case to which the general formula applies without change, all the terms being present. Forestry in America, however, has not progressed far enough to enable us to assign values to the terms T and E with any approach to accuracy. It is customary, therefore, to disregard these terms; they, of course, tend to neutralize each other. Indeed, with the present available yield tables and records of planting, the values assigned to Y and c must be more or less arbitrary. The formula thus becomes

$$S_e = \frac{Y_r - c\ (1.0p)^r}{1.0p^r - 1}.$$

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[a] Of course a forest which as a whole produces a sustained annual yield may be in its various parts managed in any of the other ways. So long as the forest as a whole produces a sustained annual yield, the management of its various parts is a matter of no concern to the problem of taxation, provided a single jurisdiction taxes the whole forest.

[b] The numerical values to be given to the terms in the formula are different, of course, for each species and each locality. This example and those that follow are more or less arbitrary. Their purpose is to illustrate the theory, not to show what may be expected from forestry in any particular case. They are, however, based to a certain extent on actual cases, and are intended to approach with a fair degree of accuracy average conditions in the United States.

[c] The figures in this example are quite conservative. For an example approaching the one given, see Forest Service Bulletin No. 26, p. 49, first example.

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For example, suppose a piece of bare or cut-over land is planted at a cost of $7 per acre. The timber is cut after sixty years, when the net value of the yield is $300 per acre. The land is then replanted, and the process repeated indefinitely. Then, $r=60$; $p=5$; $Y_r=300$; $c=7$.

$$S_e=\frac{300-7(1.05)^{60}}{1.05^{60}-1}=\frac{300-131}{17.7}=\frac{169}{17.7}=9.55.$$

This forest therefore yields a net income of $169 per acre every sixty years, and its capital value (or expectation value) is $9.55.[a] The annual income of $9.55 at 5 per cent is $0.48; that is, the forest in question, yielding $169 net every sixty years, is worth exactly the same per acre as a forest or other investment yielding $0.48 every year.[b]

1, *b*. The forest which is made to produce a sustained periodic yield by clear cutting, with natural reproduction, differs from the case just described only in the absence of the item of cost of planting. The formula is, therefore,

$$S_e=\frac{Y_r}{1.\ 0p^r-1}.$$

For example, suppose a forest will produce a net yield of $150 per acre every sixty years, by clear cutting and natural reproduction. Then $r=60$; $p=5$;

$$Y_r=150.\quad S_e=\frac{150}{1.05^{60}-1}=\frac{150}{17.7}=8.47.$$

That is, the forest yields a net income of $150 per acre every sixty years, and its capital value is $8.47 per acre.[c] This forest is worth the same as a forest yielding $0.42 per acre every year.

2. The next case in our classification is the forest producing a sustained periodic yield by selection cutting. Here, instead of taking off all the timber, only a part is removed, the time for removal being selected according to some rule which perpetuates the forest and permits the return, after a certain interval, for another cutting by the same method. The interval is apt to be chosen so that about the same yield will be obtained from each cutting. The forest is perpetuated naturally, and there is no cost for planting. The formula for this case is the same as for the preceding (1, *b*.),

$$S_e=\frac{Y_r}{1.0p^r-1}$$

For example, suppose a forest, under the method of selection cutting, produces a net yield of $15 per acre, and that an equal yield can be obtained every thirty years by the same method of cutting.

$$\text{Here } r=30;\ p=5;\ Y_r=15.\quad S_e=\frac{15}{1.05^{30}-1}=\frac{15}{3.32}=4.52.$$

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[a] These figures represent a forest in good condition. For examples resembling the above, cf. N. H. Forestry Commission, Report 1905–1906, pp. 235–249; Conn. State Forester Report, 1907, pp. 254–258.

[b] We are here disregarding any extra risk of loss in the case of the planted forest and also the whole question of the proper rate of interest at which to discount forestry investments. These questions are discussed in Chapter VI, pp. 615–618, and in the appendix to Chapter VI, pp. 618–626.

[c] The figures given in the example are probably rather conservative for a first-class forest.

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That is, the forest yields a net income of $15 per acre every thirty years, and has a capital value of $4.52 per acre.[a] This forest has the same value as one which yields $0.23 per acre every year.

III. The third group of forests contains all those where forestry is not practiced. There being no regular system of management, it is of course impossible to apply a formula based on regular sustained yield, and accurate calculations of future yield or expectation value are out of the question.

A tax on forest lands, based on earning power, may be applied theoretically in either of two ways, (1) as a tax on income, taxing the net yield of the forest when the timber is cut, or (2) as an annual tax on capital value, the capital value being the true expectation value based on all expected future incomes and expenses. Provided the two tax rates bear the proper relation to each other, the resulting tax burden will be exactly the same, whichever method of taxation is employed.[b] The relation between the two tax rates is expressed by the following equation, where t_i is the rate of the income tax, t_c the rate of the tax on capital value, and p the rate of interest:

$$t_c = t_i \times 0p.$$

For example, if the rate of interest is 5 per cent, a tax of 20 per cent on yield when cut is equivalent to a rate of 1 per cent on capital value.

The tax on yield when cut applies without distinction to all kinds of forests. For this tax it is not necessary to distinguish the different kinds of management, or even to make any special provision for the forest which is not managed under any regular plan. Each forest is simply taxed on its yield whenever any timber is cut.

The tax on capital value, on the other hand, requires the computation of expectation value. This computation differs according to the character of management, and in the case of the forest subject to no regular management is impossible.

The operation of a tax on forests based on these principles may be made clear by a mathematical example corresponding to each of the examples of forest management given above.

For our present purpose we may assume that forests are to be taxed equitably in comparison with other kinds of wealth which are under the general property tax. The proposition to offer special encouragement to forestry by means of taxation at a lower rate than other kinds of wealth have to bear is discussed elsewhere. Here we assume the ideal of an equal burden of taxation on all kinds of wealth in proportion to income. Let us assume, by way of example, that other forms of wealth are being taxed at the average rate of 1 per cent of the true value, under the general property tax.[c]

The California tax commission in 1906 adopted 1 per cent as representing the average burden of the general property tax on wealth in general in California. "Report of the Commission on Revenue and Taxation of the State of California, 1906," p. 98–100.

With an interest rate of 5 per cent, this is equivalent to a tax of 20 per cent upon net income. Applying the two methods of taxation in turn to each of the examples of forest management given above, we have the following result:

(1) The case of the forest producing a sustained annual yield is the simplest. The net income is $0.50 per acre annually. Its capital value is $10 per acre. If taxed on yield, this forest would pay an annual tax of 20 per cent of $0.50, or $0.10 per acre. If taxed on capital value, it would pay annually 1 per cent

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[a] These figures are probably rather conservative. For a similar example, cf. Forest Service Bulletin No. 26, p. 49, second example. This example was a forest of spruce with some hard woods, only the spruce being figured in the value of the cut. A number of other examples more or less similar to the one in the text may be found in the various forest working plans issued by the Forest Service and printed in its Bulletins.

[b] This assumes also, of course, that the rate of interest employed in the calculation of expectation value is the correct one for the circumstances.

[c] In Connecticut the average tax rate in 1907 was 1.3 per cent on an assessed valuation of 85 per cent. This is equivalent to a rate of 1.105 per cent on the true value. "Information relative to the Assessment and Collection of Taxes, 1908." Published by the Connecticut tax commissioner, pp. 20–21.)

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of $10, or $0.10 per acre. The tax is evidently the same, whichever basis of assessment is employed.

(2) The next example is that of the forest producing a sustained periodic yield by clear cutting, reproduced by planting. The net income, or the value of the cut less expenses, is $169 per acre, and this income occurs every sixty years. The capital value of the forest is $9.55 per acre. If taxed on yield, this forest would pay a tax of 20 per cent of $169, or $33.80 per acre, paid every sixty years at the time of cutting. If taxed on capital value, the tax would be 1 per cent of $9.55, or $0.095 per acre, paid annually. The present value of $33.80 paid sixty years from date and every sixty years thereafter (interest being at 5 per cent) is $\frac{33.8}{1.05^{60}-1}=\frac{33.8}{17.7}=\$1.91$. The present value of $0.095 paid annually forever is $\frac{0.095}{0.05}=\$1.90$. The mathematical identity of the two methods is evident.

(3) The forest producing a sustained periodic yield by clear cutting, with natural reproduction, differs from the preceding case only in the absence of an item of cost of planting to be deducted from the yield. In the example given the net yield is $150 per acre, occurring every sixty years. The capital value is $8.47 per acre. The tax based on yield would be 20 per cent of $150, or $30, paid every sixty years. The tax on capital value would be 1 per cent of $8.47, or $0.085, paid annually. The present values of these two taxes are, respectively, $\frac{30}{1.05^{60}-1}=\$1.69$, and $\frac{0.085}{0.05}=\$1.70$.

(4) Where the forest produces a sustained periodic yield by selection cutting, the expectation value is computed by the same formula as in the preceding case. In the example given the net income is $15 per acre, occurring every thirty years. The capital value is $4.52 per acre. The tax based on yield would be 20 per cent of $15, or $3, paid every thirty years. The tax on capital value would be 1 per cent of $4.52, or $0.045, paid annually. The present values of these two taxes are, respectively, $\frac{3}{1.05^{30}-1}=\$0.90$ and $\frac{0.045}{0.05}=$ $0.90, demonstrating the identity of the two methods of assessment.

(5) Where no regular management is employed, and the yield comes at irregular intervals and in irregular amounts, it is obvious that mathematical examples would be of no service. It is equally obvious that this kind of forest presents no theoretical difficulties in the case of a tax on yield when cut, but that the annual tax on capital value is impossible, since there is no way of calculating expectation value.

Assuming that the correct basis of taxation is income, and that timber lands are to bear the same relative burden of taxation as other kinds of wealth, the theory of the correct taxation of timber lands is simple. The foregoing examples are sufficient to demonstrate this. Forest lands may be taxed in one of two ways: (1) Levy a tax on the value of the net yield whenever any timber is cut, at a determined rate, assumed to represent fairly the burden of taxation on other kinds of income. This method applies without distinction to the forest producing an annual sustained yield and to the one whose yield is periodic. The difference is that in the one case the tax is paid annually; in the other it is paid at regular but longer intervals. It also applies without difficulty to the forest whose yield is irregular. (2) Estimate the capital value of the forest (i. e., its expectation value based on all future expected incomes and expenses) and levy the tax at a determined rate equivalent to the income tax rate which represents fairly the burden of taxation on other kinds of wealth. The rate of the tax on capital value is the rate of the income tax multiplied by the rate of interest. This method also applies to any forest which is producing a sustained annual or periodic yield. In the case of the annual sustained yield, the calculation of capital value is very simple, the capital value being the quotient of the annual income divided by the rate of interest. In the case of the periodic yield the problem is more complicated, requiring the calculation of the present expectation value of the forest based on all future expected revenues and expenses. This method can not be used

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in those cases where no regular management is in operation, or where the yield is so irregular as to prevent the accurate calculation of expectation value.

II. THE RATE OF INTEREST.

A most important factor in the calculation of expectation value is the rate of interest. In the examples in Section I of this appendix 5 per cent has been chosen as the rate of interest, and this rate has served as well as any other for the illustration of theoretical principles. The selection of this particular rate, however, has not been meant to carry with it any assumption that 5 per cent is in fact the correct rate at which to capitalize forest investments, nor that the selection of the rate of interest is a matter of slight importance. It is really of the most vital importance; indeed, it is hardly an exaggeration to say that it is the crux of the whole theory of the tax on expectation value. Its importance can readily be seen by a glance at the following table, which shows the expectation value and the amount of the annual tax on capital value in each of the examples discussed above, where different rates of interest are used in the calculation:

Tax on expectation value.

Rate of interest.	Example 1.		Example 2.		Example 3.		Example 4.	
	Expectation value.	Tax.	Expectation value.	Tax.	Expectation value.	Tax.	Expectation value.	Tax.
Per cent.								
3	$16.67	$0.17	$52.92	$0.53	$30.67	$0.31	$10.49	$0.10
4	12.50	.13	23.84	.24	15.79	.16	6.70	.07
5	10.00	.10	9.55	.10	8.47	.08	4.52	.05
6	8.33	.08	2.16	.02	4.69	.05	3.16	.03
7	7.14	.07	−1.87	−.02	2.63	.03	2.27	.02
10	5.00	.05	−6.04	−.06	.49	.005	.91	.009

The results of using different rates of interest are most remarkable in example 2, which is due to the presence of an original cost of planting, which increases enormously as the rate of interest is raised, until at 7 per cent this cost eats up the entire yield of the forest. This is the only case in which the expectation value can become negative. The other examples, however, are scarcely less eloquent in their testimony to the overwhelming importance of the rate of interest. When we see that a change of one unit in the rate of interest may double or even treble the amount of the tax, we begin to realize that if our tax system is to be based on expectation value all our search after an equitable tax will be a farce unless means are taken to correctly determine this factor of the problem.

In the brief time which the writer has had at his disposal for the preparation of this report it has been impossible to give the subject the thorough investigation which its importance deserves. Indeed, for all the practical purposes of this report, such a study would have little bearing, since, as is shown in the text of Chapter VI, the tax on expectation value must be rejected on other grounds as not capable of practical application under present American conditions. This subject will therefore be passed with the following brief suggestions:

That the question has never received proper investigation is evident from the character of its discussion in the technical works on forestry. In working out problems of expectation value, these works use rates of interest which are almost certainly too low, if forestry is to be considered on a commercial basis. For example, Endres uses 3 per cent in calculating expectation value.[a] Schlich, after a discussion covering three pages, decides on 2½ per cent, basing his decision mainly on the fact that at the time he was writing that was the rate paid by British consols.[b] Fernow argues in favor of a low rate of interest,[c] on

[a] Endres, "Die Besteuerung des Waldes, Forstwissenschaftliches Centralblatt, Sept.-Oct., 1899," p. 496.

[b] Schlich, "Manual of Forestry," Vol. III, 3d ed., pp. 113–116.

[c] Fernow, "Economics of Forestry," pp. 214–215.

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the grounds that interest rates are likely to fall in the future, that forests will generally be a safe investment, and that the price of wood is likely to rise. He concludes that, since trust companies and savings banks are making long-time investments at 3 and 3½ per cent, we may safely use those rates or even lower ones in calculating the value of forest investments. In an example on another page, however, he uses 5 per cent.[a]

These examples will illustrate the reasoning commonly employed on this subject, the conclusion being that forest investments should be capitalized at a relatively low rate of interest, not higher than 2½ or 3 per cent. This conclusion may possibly be valid for the settled conditions of forestry which prevail in certain parts of Europe, though even this is open to question. But for conditions such as prevail in America such reasoning and such a conclusion can not be accepted.

Instead of being lower than the ordinary commercial rate, the writer is satisfied that the rate of interest for forest investments should be fully as high as the rate on ordinary investments, or even considerably higher. Forestry is a business of a peculiar character. In the first place, the risk is very great. The danger of fire is so great that no insurance company will take the risk. There is also the risk of injury by insects, wind, etc. These risks must be taken account of in the rate of interest, and it will require more than a slight increase in the rate to fully compensate for them. To put forest investments on a par with government bonds and the better class of trust company and savings bank investments is absurd under present American conditions.

But the circumstance which above all others makes forestry a business by itself is the very long period which must generally elapse before the investment begins to yield an income. The investment of $1,000 in a perpetual annuity of $30 or $40 a year is one thing; to put capital into an investment from which no income is to be expected for fifty or sixty or even one hundred years (very probably not till after the death of the investor) is a very different thing. Innumerable investments of the first kind are being made every day, and we can determine the prevailing rate by a glance at the dealings on the stock exchange. Investments of the second kind are so rare that we are unable to say from actual dealings what the rate should be. The comparison of future with present good, on which rates of interest depend, is a psychological process, and is influenced by a multitude of considerations. One of the most important of these is the remoteness of the future good, and it is certain that the rate at which men discount future events tends to increase with the remoteness of the event. Many a man who is satisfied with an investment which yields him 3 or 4 per cent at once would not consider for a moment an investment at the same rate whose income was to commence sixty years from date. It is safe to say that, other things being equal, men will not be tempted by forestry investments unless the rate of interest is considerably higher than that of investments whose income begins at once. It is clear that we can not put forestry on a par with the better investments of trust companies and savings banks.

Even a brief examination will show the weakness of some of the arguments cited above in favor of a low rate of interest. The assumption that the rate of interest tends to fall is belied by recent history. Schlich, writing in 1895, based his rate on British consols, which paid 2½ per cent, and he has made no change in this paragraph in his third edition published in 1905. But to-day British consols yield 3 per cent on their market price, and French and German government bonds yield even higher returns. Fernow's book was published in 1902, yet even this brief time has seen a considerable rise in interest rates, and many a savings bank to-day is paying 4 per cent to depositors. On account of the depreciation of our monetary standard, resulting from the tremendous production of gold, interest rates have been rising for the past decade, and the same influence is more than likely to cause a further rise in the future. So far as the future of the rate of interest is concerned, the effect should be to cause a higher rather than a lower rate on deferred incomes.

That the price of wood is likely to rise, and so increase the profits of forestry, can not be denied. This circumstance, however, should not properly enter into the determination of the rate of interest. It should rather be taken account of in estimating the value of the future yield of the forest (the terms Y and T in the formula). Any proper estimate of the value of future yield will take

[a] Fernow, "Economics of Forestry," p. 251.

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into account the probable increase in the price of timber. This factor being thus accounted for, there is no reason for lowering the rate of interest on this account.

We may conclude, then, that as compared with ordinary investments, the income of forestry should be capitalized at a relatively high rate of interest. Further study would probably show that, if the rate of five per cent adopted for the examples above is not the correct one, it errs in being too low rather than too high.

CHAPTER VII.

PRACTICAL CONSIDERATIONS AND PROBLEMS OF ADMINISTRATION.

The practical difficulties in the way of any plan of tax reform in the United States are tremendous. The path toward scientific forest taxation is sure to be strewn with obstacles, more or less serious. The tax on yield when cut has been advocated as an underlying principle. In putting this principle into operation no two States would necessarily adopt exactly the same administrative methods or machinery. This report obviously can not go into local conditions or into minute details of administration. We must, however, discuss some of the general problems of administration and look into some of the serious practical objections which may be urged against the tax on yield when cut. The following suggestions are offered:

I. THE BASIS OF ASSESSMENT.

Shall the tax be assessed upon the gross or upon the net yield of the forest? The ideal basis for any tax is net income. Practically it is often advisable to use gross income. In the case of forest taxation the stumpage value of the timber cut would probably be the best basis of assessment. In most cases this comes very near the net yield, and it is also the simplest basis for administrative purposes.

II. EQUALIZING LOCAL INCOME.

The first difficulty in the way of the tax on yield is that it would apparently result in an irregular and uncertain revenue for many towns and counties. Three alternative plans are suggested for meeting this difficulty.

(*a*) Let the tax be administered by the State. Let a rough estimate be made of the probable average annual yield of the forests in each town or county. Applying the tax rate to this average yield will give approximately the average annual revenue which the town or county may expect from its forests. Then let this amount be paid to each town or county annually by the State. Whenever any timber was cut in the town or county the State would collect the tax. An account would be kept by the state treasurer in which the town or county would be debited with the annual payments to it from the State, and credited with all taxes collected from the forests within its borders. At stated intervals a balance would be struck between these debits and credits with accumulated interest to date. The balance on either side would be carried forward to the next time of settling. A large balance on either side would

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be avoided by altering the amount of the annual payments from time to time as experience showed they were too high or too low. Such a plan would not require an exact calculation of expectation value, since no permanent injustice could result from errors in the calculation of the annual payments from the State to the towns or counties. This plan makes the State the administrator of the forest tax and the banker for the towns or counties, thus guaranteeing to each a fairly regular income, probably more regular than the income from taxation of forest lands to-day. The State itself has a large enough territory, so that the tax would produce a fairly regular income for the whole State.

(*b*) The same result might be accomplished in another way. Let a nominal annual tax be collected from the owners of timber lands. When the timber is cut collect the tax on the yield and allow a deduction for the previous annual payments with interest to date. If, through a mistake, the annual payments had been excessive, so that, with interest, they exceeded the tax on the yield when finally cut, a rebate would be due the owner. This plan would be necessary only for forests producing an intermittent or irregular yield. Where a sustained annual yield was produced, the tax would simply be collected each year at a certain percentage of the yield. This plan has the advantage of great simplicity. It could be administered either by state or local officers, and the necessary bookkeeping would be very simple.

(*c*) A third way of avoiding the difficulty of irregular local revenue would be to make the forest tax a state tax, pure and simple, compensating the local division in some equitable way, as by a payment from the State according to some definite rule, or by the State surrendering to the local divisions some other source of revenue. Some such arrangement might be introduced by a State which happened to be remodeling its tax system as a whole.

Each of those plans has advantages and difficulties. Probably the second would best fit present conditions in the majority of States. Still other plans might be suggested. At any rate it seems reasonable to believe that no insuperable obstacle to the tax on yield will be found here.

III. THE SMALL WOOD LOT

Another administrative question arises here. To tax every farm wood lot whenever a little timber is removed would be altogether too costly and cumbersome. It might be advisable to tax wood lots having less than a certain area by a somewhat different method. Lots might be classified under some simple rule into a few grades according to quality, the tax per acre being fixed for each grade at a fairly low figure and collected annually, with an additional tax on the yield if the timber were ever entirely cut off.

IV. NECESSARY RESTRICTIONS.

This system of a special timber-land tax must apply to bona fide timber lands only. For example, the laws must be so drawn as to prevent the holding of land without taxation for merely speculative purposes under the guise that it is timber land. It might be advis-

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able to restrict the forest tax to lands not exceeding a certain value per acre, as is done in many of the present exemption laws; or by some provision in the statutes to enforce the actual use of the land for producing timber. It should not be a very difficult matter to provide the proper safeguards against this danger.

V. CUTTING IMMATURE TIMBER.

It may be necessary to make some special provision for the man who, having planted trees, changes his mind and cuts them off before they have grown to any great value. The small tax on the value of the cut might not be a fair compensation for the preceding years of exemption. This situation might be provided for by a simple classification of such lands according to quality and age of trees, with taxation at arbitrary rates for each class.

VI. MATURE TIMBER.

Shall the owner of mature timber be allowed to hold it indefinitely without taxation, or shall he begin to pay taxes as soon as the timber reaches maturity? If it is considered advisable to require some taxes from mature timber which is not cut, some plan must be devised. Here again the object might be accomplished by means of a simple classification of mature-timber land, with a small tax per acre, the regular tax on yield being collected when the timber was finally cut.

VII. TRANSITION PROBLEMS.

Some administrative problems would arise due to the transition from the present to the new system. For example, a mature forest which is cut just after the new plan has gone into effect could not equitably be taxed on its yield, since it has presumably paid its full share of taxation during all the years that the trees have been growing up. Similarly, an equitable compromise would be necessary for timber which was partly grown when the new plan was adopted.

These suggestions regarding practical problems make no pretense to having covered all the possible complications which might arise under special conditions. With regard to all such problems as these, involving special circumstances here and there, but not the general run of ordinary cases, the writer is strongly convinced that the solution should be in the adoption of certain simple, even arbitrary, working rules which aim to secure certainty and ease of administration rather than any nice adherence to theoretical principles.

VIII. EFFECT ON REVENUE.

It may be asked, what will be the effect of the tax on yield upon the revenue of the States and local divisions? Strictly speaking, this question should be answered for each State separately in the light of local conditions. In some cases it is possible that the adoption of the tax on yield might cause some temporary disturbance of the revenue system. In general, it is not believed that this method of taxing timber lands will lead to any serious reduction of revenue. If, as

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the evidence seems to show, forests are as a rule not excessively taxed to-day, there is no reason to expect any great reduction of revenue through the adoption of the tax on yield. Eventually revenue will be increased by a method of taxation which does not prevent the development of forestry. Forests paying a moderate tax are better than abandoned lands paying no tax at all. This is assuming always that the rate of the forest tax is selected so as to make forests bear the same relative burden as other kinds of wealth. It may be considered advisable to attempt to encourage forestry by a special low rate. In this case some revenue will of course be sacrificed.

IX. CONSTITUTIONALITY.

The plan of a tax on the yield of forests at a special rate, in lieu of the general property tax, will be unconstitutional in many of the States of the United States. These state constitutions stand to-day in the way of many plans for reform in state and local taxation. The movement toward their amendment is growing as part of the general programme of tax reform. If the plan of forest taxation here proposed wins favor, it will simply be an added argument for the speedy amendment of those state constitutions which are now blocking the progress of scientific tax reform.

X. TAXATION OF FORESTS IN EUROPE.

This topic is mentioned here for want of a better place. On account of the limited time for the preparation of this report, it has seemed best to omit a discussion of this subject altogether. Forestry conditions in Europe are so much more advanced than with us that the problem of taxation is less difficult. The prevailing tax systems of European countries are likewise different from ours, the general property tax having been abandoned long ago. In general, European countries base their forest taxation on a combination of ground tax and income tax. The ground tax is based on the average productive power of the forest, estimated in advance from time to time. The income tax is based on the actual income produced.

CHAPTER VIII.

CONCLUSIONS.

It is with a certain feeling of hesitancy that the following conclusions are presented. The time allowed for the preparation of this report has been out of all proportion to the magnitude and importance of the subject. Moreover, the writer expects to make a further thorough study of this subject in the immediate future. The conclusions presented in this preliminary report are therefore somewhat tentative, and it is realized that some of them may possibly have to be modified after further investigation. In the main it is believed that they will prove to be in harmony with the facts.

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I. CONTRACT BETWEEN STATE AND FOREST OWNER.

Many schemes of forest taxation have been proposed involving a contract by which the State offers some form of taxation assumed to be particularly favorable to timber lands on condition that the owner agree to plant, cultivate, or maintain his forest according to some specified plan or under the direction of some state authority. This idea has something to be said in its favor; it is also open to some serious objections. At present the writer does not feel prepared to pass judgment upon it. The plan of taxation outlined in this report does not contemplate such a contract. However, there is nothing in the principles here laid down inconsistent with the adoption of such a contract should it be deemed advisable.

II. SPECIAL FAVORS TO FORESTRY THROUGH TAXATION.

Throughout this report we have gone on the assumption that forests should bear the same relative burden of taxation as other kinds of wealth in proportion to income. As has already been shown, however, having once adopted the principle of the tax on yield, it is a simple matter to give any desired favor up to a complete exemption from taxation by merely fixing the rate of the tax. We have, therefore, in no way prejudiced the case against special favors to forestry.

This subject leads us out upon a broader field than the mere problem of correct taxation. Two questions may be asked: (1) Is the proposed encouragement to forestry by a low tax rate a proper use of the taxing power? In general, there would seem to be no reasonable objection to such a policy provided the end sought be an increase of the public welfare and provided the means be effective. Such a programme should, however, be carried out with great caution in order to prevent doing injustice to certain localities. The gain to be obtained from encouraging forestry is to the people in general, and the cost should be borne by those who enjoy the gain, not by the people of the locality where the forests happen to be. If special rates of taxation are granted to forests some arrangement must be made whereby the localities affected will be compensated for the resulting loss of revenue. (2) To what extent will the reduction of taxes prevent the destruction of forests and encourage the practice of forestry? In answering this question we are helped by the evidence presented in preceding chapters of this report. This evidence forces us to the conclusion that in this matter no great relief is to be looked for through the reduction of taxation. It has been shown that taxation has not been the cause of the cutting of our forests, and it is idle to hope that any reduction in taxation will have more than a slight influence in preventing further destruction. Taxation does not explain the present absence of forestry in America, and until other forces have become strong enough to lead to its practice special tax rates will probably not have any great influence.

It may well be that in certain places local conditions are such that great good might be accomplished by a reduced tax on forests. Where this is the case, no objection can be raised to such a programme, provided both general and local interests be safeguarded. But the solution of the general problem of forestry lies mainly outside the realm of taxation.

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This matter of a reduced tax rate must of course be distinguished from the question of just and certain taxation. We have already shown that forestry can hardly be expected to flourish until our present tax methods are replaced by a system which insures reasonable equity and certainty. The writer is of the opinion that if a tax at once equitable and dependable is guaranteed, the business of forestry will not need to ask special favors.

III. SOME ADVANTAGES OF THE TAX ON YIELD.

The general advantages of this method of taxing timber lands have already appeared throughout the preceding discussion. It remains here to call attention to certain features which have perhaps not received sufficient emphasis heretofore. In the first place the tax on yield is based upon correct principles. It bears a definite relation to income. Under this method it will be possible to make the tax on forests equitable as between different forest owners and as compared with other kinds of wealth. Still more important, the tax will be certain, a definite part of the yield, which the owner may calculate in advance and depend upon. If fire or accident destroys the yield the tax is reduced accordingly. Being due when the timber is cut, it will be paid at the time most convenient for the taxpayer. Also, being paid when the timber is cut, there will be no inducement to cut timber in order to avoid taxes or to get money with which to pay taxes. There is nothing in the tax to lead to the abandonment of cut-over lands or to prevent reforestation, provided the land can be profitably forested at all. For these and other reasons, the tax on yield, instead of being an obstacle to the practice of forestry, will be a distinct encouragement.

IV. GENERAL SUMMARY AND CONCLUSION.

We have seen that in spite of special statutes in some States timber lands are actually taxed under the general property tax everywhere in the United States. The general property tax is a thoroughly discredited method of taxation. It has proved itself a complete failure, and was abandoned long ago by every important nation except the United States. The general property tax is especially burdensome in the case of forests, because the annual increase in the value of the trees is not taken as income, but is stored up in the forest, there to be taxed over and over again till the timber is finally cut.

In certain parts of the country, and in individual cases almost everywhere, the taxation of timber lands has undoubtedly been excessive and has produced serious results on the forests. As a general rule, however, due to the prevailing habit of under assessment and the lax administration of the law, forests have not been taxed excessively. It also appears that in most cases taxation has not been responsible for the destruction of our forests or for the failure to reforest cut-over lands.

The real problem of forest taxation is in connection with the future of our timber lands rather than with their past. The preservation of the forests is a matter of the utmost importance. So far our forests have been exploited with little or no regard for the future. But the

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present methods can not last much longer. Forestry must come some time, and its early coming is a thing greatly to be desired. And whenever we are ready to seriously undertake it we will find our present methods of taxation a severe handicap. Strictly enforced, according to the letter of the law, the annual tax on the full value of the land and standing timber is almost sure to result in excessive taxation, and the timber owner can not count on the continuance of the present lenient enforcement of the law. Even if the tax might not be excessive, its uncertainty would be a serious obstacle to investment. We can hardly hope to see the general practice of forestry as long as the present methods of taxation continue.

To be equitable, taxation of timber lands like taxation of anything else should be based on income or earning power. This may be accomplished in the case of forests either by a tax on the yield when cut or by an annual tax on the capital value of the forest, based on all its expected future incomes and expenditures, i. e., on what the foresters call "expectation value." At present and for some time to come the tax on expectation value can not be generally applied to America on account of the slight development of forestry and the absence of the necessary statistical data, such as yield tables, etc. On the other hand, the tax on yield has decided advantages, both theoretical and practical, in its favor. Among others, it does not have to take account of the rate of interest, of the risk of loss by fire, or of future prices of timber.

The tax on the yield when cut is advocated as the principle on which any scientific system of forest taxation should be based. In putting this principle into practice many problems must be met. Suggestions have been made regarding the solution of some of the more important of these. It is not believed that any of these problems will prove incapable of solution.

With regard to its effect on revenue, there is little to be feared from the tax on yield. Eventually, revenue will be increased by a method of taxation which does not prevent the development of forestry. Forests paying a moderate tax are better than waste lands abandoned and paying no tax at all.

Too much confidence should not be placed in the plan to levy a special reduced tax on timber lands in the interest of forestry. It is not likely that a mere reduction of taxation will have any great influence in stopping the destruction of the forests or inducing the practice of forestry.

The tax on yield has many decided advantages. It avoids the evils of the general property tax. It is equitable and certain. It is in harmony with the peculiarities of the business of forestry, and will be a distinct encouragement to the practice of forestry. Its adoption by the States would remove one obstacle to the perpetuation of the nation's forest resources.

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REDUCTION OF TIMBER SUPPLY THROUGH ABANDONMENT OR CLEARING OF FOREST LANDS.

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SUMMARY.

The original forested area of the United States, of approximately 900,000,000 acres, has been steadily reduced by the demand for agricultural land and the increasing consumption of lumber and other forest products. The total area of improved farm land in the United States was 118,457,000 acres in 1850; 163,110,000 acres in 1860; 188,921,000 acres in 1870; 284,771,000 acres in 1880; 357,616,000 acres in 1890; 414,485,000 acres in 1900, and approximately 447,762,000 acres in 1907.

Of the total area of improved farms in 1907, not less than 65 per cent, or 292,000,000 acres, has been drawn from the original forests of the country.

The area of timbered land cut over for all forms of forest products was 2,058,000 acres in 1860; 3,468,000 acres in 1870; 4,764,000 acres in 1880; 5,841,000 acres in 1890; 8,577,000 acres in 1900, and 9,429,000 acres in 1907.

The results of the enormous drain from these two sources upon the original forests of the United States are shown by the following figures:

In round numbers, of the virgin forests of the country, in 1907 292,000,000 acres had been put into improved farms and are presumably withdrawn for all time from timber production; 335,000,000 acres, or 37 per cent of the original area, still contain merchantable timber; 180,000,000 acres are completely cut over, but in process of restocking with forest; and 65,000,000 acres, also completely cut over, are not restocking and will not produce a new growth of trees without artificial assistance.

Of the 9,429,000 acres of forest land which were cut over in 1907, 1,049,000 acres were put into farms; 5,642,000 acres are restocking with forest, and 2,737,000 acres are not restocking with forest. Of the total remaining area of merchantable timber, one-thirty-sixth is, therefore, being cut over annually. Of the acreage annually cut over, 11 per cent is put into farms; 60 per cent is restocking with forest and can be counted upon to a greater or less extent for future timber supply, and 29 per cent is not restocking and can be made of future value as timber-producing land only by artificial reforestation.

Estimating the annual growth per acre on all classes and types of forest land in the United States at 72 board feet, the original

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forests of the country produced annually 64,800,000,000 board feet of timber. The present forested area of the country, after the drain indicated to supply farming lands and various forest products, is producing a little more than 37,000,000,000 feet, or less than 58 per cent of the original production. The withdrawal of lands for agriculture, and methods of logging which leave the cut over areas unproductive of timber, have therefore caused a loss of 25,704,000,000 board feet in the annual wood crop. Of this loss, 21,000,000,000 board feet, is unavoidable, and is due to the necessary increase in the area of farm land; but the remainder of 4,680,000,000 feet is from the areas of cut over land which are not put into farms, but which, because of the methods of logging employed and the lack of protection, are not restocking with forest. This loss should be classed as national waste.

With the farms encroaching upon the forested area at the rate of 1,050,000 acres a year and with the area of cut over land which is not restocking increasing at the rate of 2,737,000 acres a year, the annual loss in timber production is increasing at the rate of 272,664,000 board feet a year. Of this increasing yearly loss of growth 75,600,000 feet may be classed as necessary, because it results from the increased acreage put under tillage; the remainder, or 197,064,000 feet, is unnecessary and can be avoided by improved methods of exploitation and protection.

The significance of this loss in the annual production of timber in the United States lies in its cumulative effect upon future supplies. If the present rate of increase in the areas of forest land which are cleared for tillage and in the areas which are cut over under such conditions that they do not restock with forest is maintained, the loss in growth of timber will amount in ten years to 272,146,000,000 board feet. If farm land is eliminated, the loss resulting from unproductive cut-over lands alone will, in the same period, aggregate 57,638,000,000 board feet. In twenty years the loss from both sources will become 596,452,000,000 board feet, and the loss from unproductive cut-over areas alone 124,144,000,000 board feet.

It is impossible to place exact limits upon the future increase in the acreage of improved farm land because of the many variable factors which enter into this question. The trend of conditions in this respect, however, is indicated by the following figures. One and nine-tenths acres of grain are required to support each person in the United States, exclusive of exports of grain or grain products of any character. In the twenty-seven years from 1881 to 1907, inclusive, the population of the United States increased at the average rate of about 1,290,000 souls a year. During the same period the grain area of the country required for home support alone increased at the rate of 2,400,000 acres annually. If the population continues to increase, not at the same ratio as during the past twenty-seven years, but at the same average number of persons per annum, the ratio of increase steadily diminishing, the country in 1950 will contain 55,470,000 more people than at present. If the same conditions as regards average grain production per acre and average consumption per capita hold true until 1950, the country will require by that year an additional grain area for home consumption only of 82,598,000 acres. The grain area at present forms 41 per cent of the total acreage required for all agricultural products. If this ratio still holds

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the total increase in improved farm land required for home consumption by 1950 will reach 202,336,000 acres. In this calculation, however, allowance has been made for possible increase in the yield per acre.

In the arid portion of the United States expansion in the acreage of farm land is limited closely by the water supply available for irrigation. The total irrigable area in the West is estimated at 60,000,000 acres. The drainage of morasses would add large areas of highly fertile land. It seems evident that not less than 100,000,000 acres of forest must be withdrawn from timber production by 1950 in order to provide a sufficient food-producing area to make the nation self-supporting.

If the present rate of increase in the cut-over areas which are not reproducing is maintained until 1950, the unproductive cut-over land will in that year amount to 182,000,000 acres. With the further withdrawal of 100,000,000 acres from the timber-growing area required by the demand for agricultural crops, the acreage of forest-producing land of all classes will by 1950 be reduced to 298,000,000 acres or about one-third of its original extent. The original annual growth of timber of 64,800,000,000 board feet will by 1950 be reduced to 21,456,000,000 feet.

Looking toward the distant future it will be of greater value to indicate corresponding conditions in the older and much more thickly settled countries of Europe than to attempt to use the present bases of estimate or comparison. The United States, for example, has a present population of 28.62 persons per square mile, as compared with 191.68 per square mile in France. The United States requires 55.11 acres in grain in each square mile in order to support its population. France requires, or would require if all the grain consumed were grown at home, 176 acres in each square mile. In the United States the annual consumption of grain per capita is 43.85 bushels, while in France it is a little over 21 bushels. If the United States should ever attain a density of population equal to that in France, which in this country would mean a total of 571,000,000 people, and should at the same time bring its average consumption per capita down to the French basis, we would require a grain area of 523,000,000 acres, and a total area in farm crops of 986,000,000 acres.

To make a less extreme comparison, if this country attained a density of population equal to that of Europe as a whole, it would contain 103 persons to the square mile, or a total of 306,000,000. If we increase the average production of grain per acre from its present figure to 29 bushels, the consumption per capita remaining unchanged, 1½ acres of grain would be sufficient to support each person in the United States, or a total grain area of 459,000,000 acres. An approximately equal area would be required for other agricultural products, making the total area under tillage 918,000,000 acres. This would require an addition of 261,000.000 acres of agricultural land to the area estimated for 1950 and would reduce the forest resources of the country to about 219,000,000 acres including the 182,000,000 acres which as has been shown will not restock itself with timber without artificial assistance.

At the same time, if the production per acre could be brought up to the highest level reached in Europe, as in England which produces nearly 11 bushels of grain per acre more than the United States, and

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if the consumption per capita were reduced to the standard of living now obtaining in Europe, a population of 300,000,000 could be amply supported by the United States with no increase in its present area of improved farm land. The indications are conclusive, however, that such changes will take place very slowly and that as far ahead as can now be foreseen this country must face a steady reduction in its forest area to meet the insistent demand for agricultural land.

The area included in the present boundaries of the United States contained, in its virgin condition, approximately 900,000,000 acres of forest. With the spread of settlement and growth in population, this area has been steadily reduced in order to satisfy two economic wants, viz, the demand for agricultural land and the steadily increasing requisition of lumber and other forest products. The increased acreage of improved farm land from decade to decade from the census of 1850 is indicated in the following table derived from the reports of the census:

TABLE I.—*Area of improved farm land in the United States from 1850 to 1907.*

State.	1850.	1860.	1870.	1880.	1890.	1900.
Alabama	4,435,614	6,385,724	5,062,204	6,375,706	7,698,343	8,654,991
Arizona			14,585	56,071	104,128	254,521
Arkansas	781,531	1,983,313	1,859,821	3,595,603	5,475,043	6,953,735
California	62,324	2,468,034	6,218,133	10,669,606	12,222,839	11,958,837
Colorado			95,504	616,169	1,823,520	2,273,968
Connecticut	1,768,178	1,830,807	1,646,752	1,642,188	1,379,419	1,064,525
Delaware	580,862	637,065	608,115	746,958	762,655	754,010
District of Columbia	16,267	12,000	8,266	12,632	9,398	
Florida	349,094	654,213	736,172	947,640	1,145,693	1,511,653
Georgia	6,378,479	8,062,758	6,831,856	8,204,720	9,582,866	10,615,644
Idaho			26,603	197,407	606,362	1,413,118
Illinois	5,039,545	13,096,374	19,329,952	26,115,154	25,669,060	27,699,219
Indiana	5,046,543	8,242,183	10,104,279	13,933,738	15,107,482	16,680,358
Iowa	824,682	3,792,792	9,396,467	10,866,541	25,428,899	29,897,552
Kansas		405,468	1,971,003	10,739,566	22,303,301	25,040,550
Kentucky	11,368,270	7,644,208	8,103,850	10,731,683	11,818,882	13,741,968
Louisiana	1,590,025	2,707,108	2,045,640	2,739,972	3,774,666	4,666,532
Maine	2,039,596	2,704,133	2,917,793	3,484,908	3,044,666	2,396,889
Maryland	2,797,905	3,002,267	2,914,007	3,342,700	3,412,908	3,516,352
Massachusetts	2,133,436	2,155,512	1,736,221	2,128,311	1,657,024	1,292,132
Michigan	1,929,110	3,476,296	5,096,939	8,296,862	9,865,350	11,799,250
Minnesota	5,035	556,260	2,322,102	7,246,693	11,127,953	18,442,585
Mississippi	3,444,358	5,065,755	4,209,146	5,216,937	6,849,390	7,594,428
Missouri	2,938,425	6,246,871	9,130,615	16,745,031	19,792,313	22,900,043
Montana			84,674	262,611	915,517	1,736,701
Nebraska			647,031	5,504,702	15,247,705	18,432,595
Nevada			92,644	344,423	723,052	572,946
New Hampshire	2,251,488	2,367,034	2,334,487	2,308,112	1,727,387	1,076,879
New Jersey	1,767,991	1,944,441	1,976,474	2,096,297	1,999,117	1,977,042
New Mexico	166,201		142,007	237,392	263,106	326,873
New York	12,408,968	14,358,403	15,627,206	17,717,682	16,389,380	15,599,986
North Carolina	5,453,977	6,517,284	5,258,742	6,481,191	7,828,569	8,327,106
North Dakota			21,322	575,206	4,638,015	9,644,520
Ohio	9,851,493	12,625,394	14,469,133	18,081,091	18,338,824	19,244,472
Oklahoma					563,728	8,574,187
Oregon	132,857	896,414	1,116,290	2,198,645	3,516,000	3,328,308
Pennsylvania	8,628,619	10,463,296	11,515,965	13,423,007	13,210,597	13,209,183
Rhode Island	356,487	335,128	289,030	298,486	274,491	180,354
South Carolina	4,072,651	4,572,060	3,010,539	4,132,050	5,255,237	5,775,741
South Dakota			21,323	575,207	6,959,393	11,285,963
Tennessee	5,175,173	6,795,337	6,843,278	8,496,556	9,362,555	10,245,950
Texas	639,107	2,650,781	2,964,836	12,650,314	20,746,215	19,576,076
Utah	16,333		118,755	416,105	548,223	1,082,117
Vermont	2,601,409	2,823,157	3,073,257	3,286,461	2,655,943	2,126,624
Virginia	10,360,135	11,437,821	8,165,040	8,510,113	9,125,545	10,094,805
Washington			192,016	484,346	1,820,852	3,465,960
West Virginia			2,580,254	3,792,327	4,554,000	5,498,981
Wisconsin	1,045,499	4,147,420	5,899,343	9,162,528	9,793,981	11,246,972
Wyoming			338	83,122	476,981	792,332
Territories		448,872				
Total	118,457,622	163,110,720	188,921,099	284,771,042	357,616,755	414,485,553

NOTE.—The figures for 1850 to 1900, inclusive, are taken from the census reports.

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Of the total area of improved farms in 1907, not less than 65 per cent has been drawn from land which was originally timbered. In other words, approximately 292,000,000 acres of the original forests of the United States had, prior to 1908, been cleared and devoted to agriculture.

The drain upon the forest areas during the last fifty years to supply the demand for lumber and other forest products is indicated in the two following tables. Table II shows by States the annual cut of lumber, exclusive of other forest products, by decades from 1860 to 1907. Table III shows the estimated area cut over annually during the same period for all forms of forest products.

TABLE II.—*Cut of lumber in the United States from 1860 to 1907.*

[In thousands of board feet.]

State.	1860.	1870.	1880.	1890.	1900.	1907.
Alabama	156,302	84,943	251,851	586,143	1,096,539	1,224,967
Arizona		625				72,134
Arkansas	96,575	84,025	172,503	526,091	1,595,933	1,988,504
California	333,620	326,691	304,795	515,823	734,232	1,345,943
Colorado		20,273	63,792	79,906	133,746	134,239
Connecticut	49,121	96,315	64,427	48,277	107,594	140,011
Delaware	23,013	25,315				50,892
District of Columbia	1,760	1,875				
Florida	123,054	130,746	247,627	411,436	788,905	839,058
Georgia	202,433	252,773	451,788	572,970	1,308,610	853,697
Idaho		3,553	18,204	27,800	65,331	513,788
Illinois	223,441	284,173	334,244	218,938	381,584	141,317
Indiana	371,009	770,297	915,943	707,115	977,878	504,790
Iowa	182,100	302,143	412,578	508,816	351,769	144,271
Kansas	130,290	108,524				
Kentucky	207,985	228,880	305,684	420,820	765,343	912,908
Louisiana	101,003	98,500	133,472	303,591	1,113,423	2,972,119
Maine	597,313	712,234	566,656	564,243	756,515	1,103,808
Maryland	50,734	93,842	123,336	81,078	183,393	213,786
Massachusetts	196,096	222,304	205,244	208,655	342,058	364,231
Michigan	608,617	1,996,650	4,122,572	4,245,717	3,012,057	1,827,685
Minnesota	104,800	268,698	563,974	1,079,403	2,341,619	1,660,716
Mississippi	152,685	147,542	168,747	452,797	1,202,334	2,094,485
Missouri	257,085	397,694	399,744	395,755	715,968	548,774
Montana		26,935	21,420	89,511	255,685	343,814
Nebraska	27,945	17,388				
Nevada		27,031				
New Hampshire	107,809	267,884	292,267	266,890	562,258	754,023
New Jersey	135,263	171,582	109,679	32,285	72,660	39,942
New Mexico	3,762	9,827				113,204
New York	883,133	1,327,389	1,184,220	909,990	874,754	848,394
North Carolina	98,001	125,015	241,822	509,436	1,278,399	1,622,387
Ohio	439,990	639,699	910,832	541,076	957,239	529,087
Oklahoma						140,015
Oregon	57,500	63,388	177,171	444,565	734,181	1,635,563
Pennsylvania	916,172	1,802,436	1,733,844	2,113,267	2,321,284	1,734,729
Rhode Island	6,343	16,079				32,855
South Carolina	93,803	74,813	185,772	197,940	466,109	649,058
South Dakota		4,517				34,841
Tennessee	185,709	211,918	302,673	450,097	839,463	894,968
Texas	146,184	122,553	328,968	839,724	1,230,904	2,229,590
Utah	12,125	41,339				14,690
Vermont	77,378	220,320	322,942	370,155	365,869	373,660
Virginia	184,913	131,941	315,939	409,804	956,169	1,412,477
Washington	99,530	81,724	160,176	1,061,560	1,428,205	3,777,606
West Virginia		92,300	180,112	299,709	773,583	1,395,979
Wisconsin	384,702	945,670	1,542,021	2,817,200	3,361,943	2,003,279
Wyoming		16,750				17,479
All others			200,317	126,270	226,977	5,891
Total	8,029,318	13,166,212	18,087,356	23,494,853	34,780,513	40,256,154

NOTE.—The figures for 1880 to 1907, inclusive, are taken from the census reports. The census reports for 1860 and 1870 give only the value of lumber cut in the respective States. The best estimates from other sources indicate a total cut in the United States of approximately 8,000,000,000 feet in 1860 and 13,000,000,000 feet in 1870. By comparing these figures with the total value

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of the lumber cut, as given in the census reports for the same years, an average value per thousand feet of $12 in 1860 and $16 in 1870 is indicated. The value of the cut in each State, as given in the census, was converted into board feet by using these divisors for the respective years.

TABLE III.—*Estimated area cut over annually in the United States from 1860 to 1907, including cordwood and all forms of forest products.*

State.	1860.	1870.	1880.	1890.	1900.	1907.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Alabama	42,201	22,935	67,999	158,263	336,965	531,000
Arizona		168				33,000
Arkansas	26,075	22,686	46,575	142,044	430,902	550,000
California	43,370	42,469	39,623	67,056	95,450	172,300
Colorado		5,473	17,203	21,574	36,111	96,000
Connecticut	13,262	26,005	17,395	13,034	29,050	40,000
Delaware	6,213	6,835				9,000
District of Columbia	475	506				
Florida	33,224	37,631	66,859	111,087	213,004	340,000
Georgia	54,656	68,248	121,982	154,701	353,324	317,250
Idaho		959	4,915	7,506	17,639	75,000
Illinois	60,328	76,726	90,245	55,123	103,027	25,650
Indiana	100,172	207,980	247,304	190,921	264,027	60,000
Iowa	49,167	97,778	111,496	153,580	94,977	6,300
Kansas	35,178	29,301				2,800
Kentucky	29,155	61,797	82,534	113,621	206,642	428,824
Louisiana	27,270	26,595	36,037	81,969	300,624	500,000
Maine	161,274	192,303	152,997	152,345	204,259	250,000
Maryland	13,703	25,337	33,300	21,891	49,516	87,600
Massachusetts	52,945	60,062	55,415	56,336	92,355	110,000
Michigan	164,326	539,077	1,126,594	1,146,343	813,254	400,000
Minnesota	28,296	72,548	152,273	291,438	362,237	210,000
Mississippi	41,224	39,849	45,561	122,255	324,630	450,000
Missouri	69,412	107,377	107,930	106,853	193,311	165,087
Montana		7,272	5,783	24,167	69,038	99,309
Nebraska	6,845	4,694				1,250
Nevada		7,298				6,300
New Hampshire	29,108	72,328	78,912	72,080	151,809	220,000
New Jersey	36,521	36,326	33,613	8,716	19,618	5,000
New Mexico	1,015	2,663				38,000
New York	238,445	358,395	319,739	245,697	236,183	287,875
North Carolina	26,460	33,754	65,291	137,547	345,167	447,125
North Dakota						1,500
Ohio	118,797	172,718	245,924	146,090	258,454	106,200
Oklahoma						158,240
Oregon	4,197	4,627	12,933	32,453	53,595	120,000
Pennsylvania	247,366	486,657	468,137	570,582	626,746	474,525
Rhode Island	1,712	4,341				3,780
South Carolina	25,326	20,199	50,158	53,445	126,849	168,900
South Dakota		1,219				8,500
Tennessee	50,141	57,217	81,721	121,526	226,708	309,400
Texas	38,469	33,089	88,821	226,725	332,344	600,000
Utah	3,273	11,161				22,200
Vermont	20,892	59,486	87,194	99,841	98,784	100,000
Virginia	49,926	35,624	85,203	110,647	268,165	380,000
Washington	4,578	3,759	7,368	48,832	65,697	172,000
West Virginia		24,947	48,630	80,921	208,867	329,785
Wisconsin	103,869	255,330	406,345	660,644	907,729	492,000
Wyoming		4,522				18,000
All others			54,085	34,092	61,283	
Total	2,058,866	3,468,171	4,764,094	5,841,945	8,577,440	9,429,691

NOTE.—The figures for 1907 are based upon statistics collected by the Forest Service during 1908, by counties and States, for all forested portions of the United States. A comparison of the total area cut over in 1907 with the total lumber cut of that year, the Pacific Coast States excepted in both cases, indicates that for every thousand feet of lumber manufactured a total area of approximately 0.268 acre is cut over for all forms of forest products. By the use of this factor, the annual cut of lumber in each State for the years preceding 1907, as given in the foregoing table, was converted into the area cut over for all forest products. This method is based upon the assumption that the cut of minor forest products has increased proportionately with the cut of lumber. Separate factors were worked out for the States of California, Oregon, and Washington by comparing in each case the cut of 1907 in board feet and in acres. These factors are, respectively, 0.128 for California, 0.073 for Oregon, and 0.046 for Washington.

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The totals of the foregoing table show forcibly the steady increase in the drain upon the forest areas of the United States required to supply the consumption of lumber, cord wood, pulp, and other wood products, reaching in 1907 a figure close to 9,500,000 acres.

The next question which presents itself is, Just where do we now stand both as regards remaining areas of merchantable timber and possibilities of future production on areas previously cut over? Table IV gives an estimate of the area in each State which still contains merchantable material, although in several States a considerable percentage of this area has been culled of a portion of the stand, together with those cut-over areas which are restocking with forest and those which are not restocking, respectively.

TABLE IV.—*Areas of merchantable timber, cut-over land which is naturally restocking with forest, and cut-over land which is not restocking.*

State.	Merchantable timber.	Cut-over land restocking.	Cut-over land not restocking.
	Acres.	*Acres.*	*Acres.*
Alabama	8,338,564	11,857,870	1,844,836
Arizona	10,800,000	442,000	520,000
Arkansas	18,000,000	11,416,000	100,000
California	21,600,000	1,960,000	771,800
Colorado	7,900,000	2,100,000	525,000
Connecticut	600,000	1,144,800	10,000
Delaware	154,680	242,160	5,000
Florida	9,000,000	12,058,211	3,014,553
Georgia	11,000,000	12,203,978	1,428,820
Idaho	22,120,000	1,640,000	215,000
Illinois	1,270,653	878,418	193,395
Indiana	1,685,000	3,081,400	400,000
Iowa	131,700	243,400	106,900
Kansas	104,000	24,000	7,000
Kentucky	6,389,540	2,294,475	200,000
Louisiana	9,452,800	6,666,960	1,292,000
Maine	10,682,800	4,500,000	400,000
Maryland	398,230	1,786,326	600,000
Massachusetts	1,972,950	1,000,000	365,382
Michigan	11,000,000	3,000,000	10,687,200
Minnesota	6,000,000	9,055,020	15,093,200
Mississippi	15,000,000	3,985,008	2,656,672
Missouri	7,487,987	9,825,567	1,166,835
Montana	17,000,000	1,445,000	554,000
Nebraska	40,000	14,000	.....
Nevada	5,150,000	27,000	104,000
New Hampshire	2,463,066	1,549,347	380,000
New Jersey	500,000	1,049,053	519,819
New Mexico	7,400,000	260,000	78,000
New York	6,007,192	5,907,192	2,262,877
North Carolina	9,379,000	10,114,600	1,950,000
North Dakota	102,600	56,500	14,680
Ohio	2,400,000	2,603,600	670,000
Oklahoma	2,136,000	1,000,000	20,000
Oregon	23,326,480	1,950,000	852,000
Pennsylvania	5,000,000	8,592,480	1,000,000
Rhode Island	155,477	214,376	10,000
South Carolina	3,741,000	7,361,800	1,400,000
South Dakota	1,323,040	84,000	17,700
Tennessee	7,200,000	7,479,680	1,220,000
Texas	11,247,800	3,438,800	3,000,000
Utah	6,700,000	650,000	480,000
Vermont	2,000,000	1,708,736	.....
Virginia	5,783,200	7,713,480	1,471,800
Washington	15,740,000	2,900,000	516,000
West Virginia	3,900,000	3,689,040	1,400,000
Wisconsin	5,600,000	8,663,840	5,500,000
Wyoming	9,540,000	126,300	22,200
Total	334,923,759	180,006,217	65,046,669

NOTE.—This table is compiled from reports by county clerks during the summer of 1908. The totals for several States as thus obtained are undoubtedly incorrect, and are presented simply as a basis for discussion.

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It appears, therefore, that of the originally forested area of the United States 292,000,000 acres have been put into improved farms and are presumably withdrawn for all time from timber production; approximately 335,000,000 acres, or about 37 per cent of the original area, still contain merchantable timber; 180,000,000 acres are completely cut over but restocking with forest; and a little more than 65,000,000 acres, also completely cut over, are not restocking and will not produce a new growth of trees without artificial assistance.

The United States is cutting annually approximately 9,500,000 acres, or about one thirty-sixth of its total area, of merchantable timber. Of the acreage annually cut over, it is estimated that 11 per cent, or 1,050,000 acres, is put into farms; that 60 per cent, or 5,642,000 acres, is restocking with forest and can be counted upon, to a greater or less extent, for future timber supply; and that 29 per cent, or 2,737,000 acres, is not restocking and can be made of future value as timber-producing land only by artificial reforestation.

The annual growth of wood on all classes and types of forest land in the United States, including cut-over areas which are restocking, is estimated at 12 cubic feet, or 72 board feet, per acre. On this basis the original forests of the country, covering 900,000,000 acres, produced annually 64,800,000,000 board feet of timber, or enough to supply fully the annual consumption of lumber, cord wood, and every kind of forest product up to within the last ten years. On the same basis the annual growth of wood on the present forested area of the United States of 515,000,000 acres, including land bearing merchantable timber and cut-over areas which are restocking, is a little more than 37,000,000,000 feet, less than 58 per cent of the original production. Regardless, therefore, of the actual amount of timber which has been cut from year to year, the clearing of forest acres for agriculture and methods of logging which leave the cut-over land in such condition that natural reproduction is not possible have caused a loss of 25,704,000,000 board feet in the annual wood crop of the country. Of this amount a little over 21,000,000,000 feet is an unavoidable loss, resulting from the necessary increase in the area of farm land. There is, however, a present annual loss in the wood crop of the country of 4,680,000,000 board feet on the area of cut-over land which is not put into farms but which, because of the methods of logging employed and the lack of protection, is not restocking with forest. It has been shown, furthermore, that the farms are encroaching upon the forested areas at the rate of 1,050,000 acres a year and that the area of cut-over land which is not reforesting is increasing at the rate of 2,737,000 acres a year. In other words, the annual loss in growth resulting from the withdrawal of areas from timber production is increasing at the rate of 272,664,000 board feet a year. Of this increase in the yearly loss of growth, 75,600,000 feet may be classed as necessary, because it results from the increased acreage put under tillage; a loss of 197,064,000 feet, arising from the cut-over lands which are not put to any economic use and at the same time are not restocking with forest, should be classed as unnecessary, or national waste.

The significance of this steady decrease in the growing stock of the country lies in its cumulative effect upon future timber supplies. The loss in growth of timber on the areas which have been and are being

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withdrawn from forest production, either as farm land or as non-restocking cut-over land, if the present rate of increase is maintained, will amount in ten years to 272,146,520,000 board feet. If the element of farm land is eliminated, the loss resulting from the unproductive cut-over lands alone will, in the same period, aggregate 57,638,520,000 board feet. In twenty years the loss from both sources will become 596,452,920,000 board feet, and from the unproductive cut-over lands alone 124,144,920,000 board feet.

The greatest and most permanent factor in reducing the annual growth and future supply of timber in the United States has been the necessary clearing of forest-producing lands for cultivation. It is therefore pertinent to inquire what limits, if any, can be placed upon the increase in improved farm land and the proportionate decrease in forest-producing land. So many factors enter into this question—the future increase in population, the extent of agricultural exports in the future, the probable increase in the average production per acre, the probable decrease in the consumption per capita—that there is little reliable basis for even approximate estimates. It will be attempted simply to indicate the present trend as to the increase in the crop-producing area and to suggest its future limits if certain broad assumptions are accepted.

Table V has been prepared to furnish a basis of comparison between the increase in population in the United States from decade to decade and the accompanying increase in the acreage, production, and home consumption of the staple grains.

TABLE V.—*The population of the United States, by decades, compared with the acreage, yield, and home consumption of the staple grains—wheat, corn, oats, rye, barley, buckwheat.*

Year.	Total crop.	Exports.	Home consumption.	Area required for total crop.	Area required for home consumption.	Population.
	Bushels.	*Bushels.*	*Bushels.*	*Acres.*	*Acres.*	
1850	867,453,967			40,191,738		23,191,876
1860	1,239,039,947			59,838,074		31,443,321
1870	1,387,299,153			69,254,016		38,558,371
1880	2,718,193,501	407,634,224	2,310,559,277	120,926,286	98,653,642	50,155,783
1890	2,518,261,647	285,308,568	2,232,953,079	140,611,020	122,340,680	62,622,250
1900	3,528,946,736	675,662,050	2,853,284,686	158,304,626	121,317,441	76,085,794
1907	4,180,303,000	454,622,632	3,727,680,368	186,153,000	163,718,365	85,000,000

NOTE.—The crop, export, consumption, and acreage statistics in this table were compiled from the following publications of the Department of Agriculture: Agricultural Statistics, 1907 (reprinted from "Yearbook of Department of Agriculture for 1907"); Bulletin No. 55, Meat Supply and Surplus; Bulletin No. 34, Agricultural Exports of the United States, 1851–1902.

The population for the years 1850 to 1900, inclusive, is taken from the census reports. The population for 1907 is estimated.

The exports include flour, oatmeal, corn meal, bran, and middlings, and the estimated amount of grain consumed in producing the meat and meat products which are exported. This was arrived at as follows: The total exports of meat and meat products, live animals being reduced to dressed weight, were approximately 1,474,000,000 pounds in 1880, 1,612,600,000 pounds in 1890, 2,433,035,000 pounds in 1900, and 2,244,422,580 pounds in 1907. The ratio of 1 bushel of corn per each 11 pounds of meat was applied to these figures and the results included in the total grain exports of the respective years.

The exports do not include breadstuffs and other manufactured articles, since exports of this character are largely offset by imports.

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The area required for home consumption was determined by dividing the amount of each kind of grain consumed in the United States in each of the respective years by the average yield per acre for that year.

From the foregoing table it will be noted that in the twenty-seven years from 1881 to 1907, inclusive, the grain area of the United States required to support the home population, wholly exclusive of exports, increased at the rate of approximately 2,400,000 acres annually. During the same period the population of the country increased at the rate of almost 1,290,000 souls a year. In other words, 1.9 acres of grain are required to support each person in the United States and the grain area of the country must be increased by that amount for each person added to our population. If we assume that the population continues to increase, not at the same ratio as during the past twenty-seven years but at the same average number of persons per annum, a far more conservative estimate, the country in 1950 will contain 55,470,000 more people than at present. If we assume, further, that the same conditions as regards average grain production per acre and average consumption per capita which have obtained during the last twenty-seven years will hold true until 1950, the country will require by that year an additional grain area for home consumption only of 82,958,000 acres. The grain area, however, forms but 41 per cent of the total acreage required for all agricultural products. If this ratio still holds, the total increase in improved farm land required for home consumption only by 1950 will reach 202,336,000 acres.

Outside of the areas of the United States, which were originally forested and which are coincident with the regions of abundant rains, expansion in the acreage of farm land is limited by water supply available for irrigation and by the areas susceptible of dry farming. The Reclamation Service estimates the total irrigable area in the West at 60,000,000 acres. No exact limits can be placed upon the area which sooner or later will be brought under tillage through the development of dry farming. It is probable, however, in view of the customary, if not essential, practice of fallowing the land in alternate years, that the crop-producing area added in any one year under dry farming will not exceed 40,000,000 acres. After making these allowances to cover the land which may be brought into cultivation outside of the forested regions, it is evident, under the assumptions above stated, that not less than 100,000,000 acres of forest must be withdrawn from timber production by 1950 in order to provide a sufficient food producing area to make the nation self-supporting.

It has been shown that of the original forested area in the United States 65,000,000 acres are completely cut over and are not restocking with timber and that this area is increasing annually at the rate of 2,737,000 acres. If this rate of increase is maintained until 1950, the unproductive cut-over land will in that year amount to 182,000,000 acres. With the further withdrawal of 100,000,000 acres from the timber-growing area required by the demand for agricultural crops, the acreage of forest-producing land of all classes will by 1950 be reduced to 298,000,000 acres, or about one-third of its original extent.

In any attempt to forecast conditions, the present bases of estimate or comparison are untrustworthy. It will be of greater value simply

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to indicate corresponding conditions in the older and much more thickly settled countries of Europe. Table VI shows the essential statistics of population, grain area, yield, and consumption in the United States compared with several European countries.

TABLE VI.—*Density of population, area in grain per square mile, average yield, and per capita consumption in the United States, compared with the most densely populated countries of Europe.*

Country.	Population per square mile.	Acres in grain per square mile.	Acres in grain per square mile required for home consumption.	Average yield per acre.	Annual consumption per capita.
				Bushels.	*Bushels.*
United States	28.62	62.68	55.12	22.45	43.85
France	191.68	163.20	176.00	23.27	21.02
Germany	280.56	174.06	208.64	31.94	23.71
Italy	303.73	184.96	206.72	14.82	10.09
Denmark	171.56	194.56	264.32	31.04	47.83
United Kingdom	349.91	65.28	183.68	32.92	17.25

NOTE.—The statistics for the United States are for the year 1907 and compiled from Table V. The statistics for the European countries are for the year 1905 and compiled from Bulletin 68 of the Department of Agriculture, entitled "Cereal Production of Europe." The grain area per square mile required for home consumption includes net imports, reduced to an acreage basis by dividing the imports of each kind of grain by the average yield per acre of the same grain in the respective countries. In the average yield per acre the net imports, reduced to an acreage basis as above, are included, the aim being to show as closely as possible the grain area required if each country were self-supporting. In the European statistics, exports and imports of meat or manufactured food products are not considered. Maslin, spelt, millet, and einkorn are included in the statistics for the countries where these grains are grown.

If the United States, for example, should ever attain a density of population equal to that in France, which in this country would mean a total of 571,000,000 souls, and should at the same time bring its average consumption per capita down to the French basis, we would require a grain area of 523,000,000 acres. In France, grain forms 53 per cent of the total area under cultivation. On that basis we would require, therefore, a total area in farms of 986,000,000 acres.

If the density of population became as great as in Germany, Italy, Denmark, or the United Kingdom, as indicated in the foregoing table, a still greater area under tillage would be required.

To make a second and less extreme comparison: Europe as a whole, with its seacoast, forested mountains, and great interior steppes, corresponds in a general way with the physiographic conditions in the United States. If this country attained a density of population equal to that of Europe as a whole, it would contain 103 persons to the square mile, or a total of 306,000,000.

Let us assume, further, that the average production of grain per acre is increased meanwhile from its present figure of 22.45 bushels to 29 bushels and that the consumption per capita remains unchanged. One and a half acres of grain would then be required for each person in the United States, or a total grain area of 459,000,000 acres. An approximately equal area would be required for other

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agricultural products, making the total area under tillage 918,000,000 acres. On the other hand, the preceding table indicates very clearly that if the production per acre were brought up to the highest level reached in Europe—namely, in Germany or the United Kingdom—and the consumption per capita reduced to the figures which now obtain in any of the European countries specified, except Denmark, a population of 300,000,000 could be amply supported by the United States with no increase in its present area of improved farm land. The indications are conclusive, however, that such changes will take place very slowly, and that as far ahead as can now be foreseen this country must face a steady reduction in its forest area to meet the insistent demand for agricultural land.

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UTILIZATION OF WOOD WASTE BY CHEMICAL AND OTHER MEANS.

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The term "wood waste" as employed in this article includes discarded or unutilized wood or wood products which are depreciating in value through natural processes of decay, etc., which are being destroyed in order to get them out of the way, or which are simply unrecovered by-products.

CLASSIFICATION AND POSSIBLE USES OF WASTE.

Wood waste may be classified under three heads: (1) Natural waste, (2) primary waste, and (3) secondary waste.

Under (1) may be placed that waste which occurs as the result of the natural death and decay of mature, uncut trees. Such waste may consist of species of little value for which no extensive uses have been found, or valuable species which for various reasons can not be profitably handled.

Under (2) may be classified those materials which are discarded in the process of manufacture but still remain wood in some form, even though greatly altered mechanically. Such a waste includes that portion of the tree discarded in logging and sawmill operations, building and workshop refuse, etc., and may be further subdivided according to the particular form in which it occurs, as tops, stumps, butts, cull logs, slabs, edgings and trimmings bark, sawdust, shavings, etc.

Under (3) may be classified all forms of waste wood products which occur as a result of complete chemical alteration of the wood or which are by-products of ordinary methods of treating lumber; as sulphite liquor from pulp mills, pyroligneous acid from southern pine distillation, and turpentine from dry kilns.

In any young country richly endowed with forest lands wastes of the above nature invariably appear. As a rule the trees are cut for some special purpose, such as lumber, and it is impossible to utilize every portion of the tree in the production of this particular material. Until profitable uses are found for all parts, these wastes are bound to occur and are, to a certain extent, excusable. When, however, profitable methods for the utilization of these discarded portions are discovered, or when improvements in the methods of cutting and sawing make it possible to avoid much of the waste, it is criminal not to put such methods and improvements into operation.

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As the civilization of a country progresses, its people develop new requirements and demand new and more expensive ways of gratifying them. In this manner new forms of wastes are often developed, although the new requirements may be to a certain extent satisfied by former waste materials.

The extent to which a country utilizes its waste may, in a sense, be taken as a measure of its development, and all the various factors which enter into the development of that country have an intimate bearing on the subject. Such utilization invariably starts locally, but, as progress is made, it takes on more and more national proportions. It is stimulated by many things, the most important of which are competition and the depletion of natural resources.

So long as the demand for the chief products of any industry exceeds the production, and profits are good, little thought is given to by-products. When, however, the industries have become thoroughly established, and competition in its various phases has become so great that the profits are reduced to a minimum, the eyes of the industrial firms are opened to the necessity of practicing the greatest possible economy. As competition of this nature increases, cheaper raw material and cheaper methods of production are provided, if possible; but it is generally the case that profits are more and more derived from the utilization of former waste materials.

Depletion of natural resources curtails production, forcing the people to seek substitutes, and very often waste materials are resorted to as substitutes for the chief products of the industry in which these wastes occur. For example, in many European countries where the forest resources have been greatly reduced, substitutes for lumber are commonly made from sawdust, a waste from the lumber industry.

Nor are competition and depleted resources the only factors which stimulate such forms of economy. With the country's development the desires and necessities of the people increase, and the number of commercial products increases, thus enlarging the opportunity for making substitutes. Such changes are bound to result in finding uses for new products and new uses for old ones. Then, too, the actual ability of the people to handle perplexing problems in a new country is only perfected gradually. The development of no two countries has ever been exactly the same, and the people very often have to be educated by experience to the point where they can solve their own particular problems, although a knowledge of the similar experience of other nations is generally of value.

Now, let us look at the other side of the subject:

There are many things which tend to retard waste utilization, even when there is a most pressing need for it. Among these may be mentioned:

1. Lack of demand for the products which may be obtained, or unfavorable economic conditions which make their production too costly.

2. Ignorance of the methods employed in other countries in which similar problems have arisen and of those employed in allied industries.

3. Prejudice in favor of a staple article which has long been used for a specific purpose, even though a new article may answer the

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purpose as well as or even better than the old one, and lack of business organization to overcome this prejudice.

The advantages to be derived from utilizing waste are ordinarily looked upon by the individual from a standpoint of immediate gain to himself; the ultimate result, however, of such utilization is usually to increase not only the individual wealth by the amount of profit, but also the total wealth of the whole country by an even greater amount. And, further, unless the utilization of waste is put into effect as soon as it is found to be practicable, future development will be retarded by depleted natural resources.

The United States has now reached that stage in its development where it is face to face with a timber famine. The demands of the people are great, and the competition of the great industrial concerns to obtain control of natural resources (a most serious form of competition) is very keen. Such a condition of affairs should stimulate the large industries to adopt the far-sighted policy of practicing the strictest economy in the utilization of the raw materials under their control, but, strange to say, until recently very little attention has been given to the subject of the utilization of wood waste, and at present there seems to be a general lack of knowledge of the methods to be employed or the results to be obtained.

NATURAL WASTE.

It is impossible to obtain a close estimate of the annual amount of natural waste, and it will therefore be treated only in general. The waste which comes under this heading may be classified as follows: (1) Accessible timber which does not have a sufficiently high value for lumber to pay for extensive cutting; (2) timber which occurs in inaccessible localities; and (3), valuable decaying timber on lands held for future logging operations. The natural waste from only the first class might, however, be checked by new methods of utilization, and this class only will be discussed here.

Scrub pine in the East, and white fir, Engelmann spruce, lodgepole pine, and lowland fir in the West, are the principal species of this class. None of these trees has a high value for lumber, and the only one which was cut in sufficient quantity to be mentioned in the census report for 1907 was the white fir. The estimated stand of white fir in Oregon and California alone is 3,200,000,000 board feet, and considerable amounts also occur in northern Arizona and New Mexico. No estimates of the total amounts of standing Engelmann spruce are available, but over 1,500,000,000 board feet have been reported as occurring on four national forests. Scrub pine is said to form about 20 per cent of the wooded area of Maryland and 10 per cent of the wooded area of Virginia. The supply of lodgepole pine and lowland fir is also very large. None of these species are at the present time used to any appreciable extent and in some cases they greatly hinder the growth of more desirable woods.

A method for the utilization of this timber in such quantities as to make extensive cutting practicable would be of assistance in preventing much of the natural waste. Recent work of the Forest Service has shown that all of the species mentioned can be made into a commercial quality of paper pulp by the ordinary sulphite process.

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The white fir and Engelmann spruce give especially good pulp, the product obtained from the former being even superior in some respects to that from the standard pulp wood—eastern spruce. In view of the facts that the price of pulp wood is steadily advancing and the demand for pulp and paper products is increasing, the possibility of utilizing this timber is very encouraging.

Another method which offers great possibilities in the prevention of natural waste by the utilization of certain species, which on account of their poor lasting qualities do not now possess a high commercial value—the method of preservative treatment—is discussed by another writer.

PRIMARY WASTE.

Species.	(1) Lumber produced in 1907.[a]	(2) Equivalent wood volume.[b]	(3) Total volume of logs.[c]	(4) Slabs, trimmings, and edgings.[d]
	Board feet.	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*
Total	40,256,154,000	3,355,000,000	6,580,000,000	1,445,000,000
Yellow pine	13,215,185,000	1,101,000,000	2,160,000,000	475,000,000
Douglas fir	4,748,872,000	397,000,000	780,000,000	171,000,000
White pine	4,192,708,000	349,000,000	684,000,000	150,000,000
Oak	3,718,760,000	310,000,000	608,000,000	134,000,000
Hemlock	3,373,016,000	281,000,000	551,000,000	122,000,000
Spruce	1,726,797,000	144,000,000	282,000,000	62,000,000
Western pine	1,527,195,000	127,000,000	249,000,000	55,000,000
Maple	939,073,000	78,000,000	153,000,000	34,000,000
Poplar	862,849,000	72,000,000	140,000,000	31,000,000
Cypress	757,639,000	66,000,000	130,000,000	29,000,000
Chestnut	653,239,000	56,000,000	110,000,000	24,000,000
Beech	430,005,000	36,000,000	70,000,000	15,000,000
Birch	387,614,000	32,000,000	62,000,000	14,000,000
Basswood	381,088,000	32,000,000	62,000,000	14,000,000
Cottonwood	293,161,000	23,000,000	45,000,000	10,000,000
All others	3,048,853,000	254,000,000	498,000,000	114,000,000

Species.	(5) Absolute waste in trimmings and edgings.[e]	(6) Sawdust.[f]	(7) Absolute waste in sawdust.[g]	(8) Bark.[h]	(9) Tops, stumps and cull logs.[i]
	Cubic feet.	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*
Total	450,000,000	920,000,000	92,000,000	854,000,000	1,640,000,000
Yellow pine	147,000,000	303,000,000	30,000,000	281,000,000	540,000,000
Douglas fir	53,000,000	109,000,000	11,000,000	101,000,000	195,000,000
White pine	47,000,000	96,000,000	10,000,000	89,000,000	171,000,000
Oak	42,000,000	85,000,000	9,000,000	79,000,000	152,000,000
Hemlock	38,000,000	77,000,000	8,000,000	72,000,000	138,000,000
Spruce	19,000,000	40,000,000	4,000,000	37,000,000	70,000,000
Western pine	17,000,000	35,000,000	4,000,000	32,000,000	62,000,000
Maple	10,000,000	21,000,000	2,000,000	20,000,000	38,000,000
Poplar	10,000,000	20,000,000	2,000,000	18,000,000	35,000,000
Cypress	9,000,000	18,000,000	2,000,000	17,000,000	32,000,000
Chestnut	8,000,000	15,000,000	2,000,000	14,000,000	27,000,000
Beech	5,000,000	10,000,000	1,000,000	9,000,000	17,000,000
Birch	4,000,000	9,000,000	1,000,000	8,000,000	15,000,000
Basswood	4,000,000	9,000,000	1,000,000	8,000,000	15,000,000
Cottonwood	3,000,000	6,000,000	1,000,000	6,000,000	11,000,000
All others	34,000,000	70,000,000	7,000,000	65,000,000	125,000,000

[a] Census reports for 1907.
[b] Obtained from the figures in column 1 by dividing by 12,000.
[c] Obtained from the figures in column 2 by dividing by 0.51.
[d] Obtained from the figures in column 3 by multiplying by 0.22.
[e] Obtained from the figures in column 4 by multiplying by 0.31.
[f] Obtained from the figures in column 3 by multiplying by 0.14.
[g] Obtained from the figures in column 6 by multiplying by 0.10.
[h] Obtained from the figures in column 3 by multiplying by 0.13.
[i] Obtained from the figures in column 3 by dividing by 4, the estimated ratio of tops to logs being 1:4.

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This table was prepared largely from the estimates of Mr. Margolin on milling wastes in which the slabs, trimmings, edgings, etc., were given as 22 per cent, sawdust as 14 per cent, and bark as 13 per cent of the total log; the woods waste, including tops, stumps, and cull logs, was estimated as 20 per cent of the total tree. In making computations for the table, the above percentages, which are to be considered as averages for all species, were applied to each species separately, but the figures obtained are for all practical purposes sufficiently close to the actual total production of these by-products.

In collecting statistics, estimates were also obtained for the proportion of some of these products absolutely wasted. The reports from all the mills answering inquiries showed a total production of 1,873,246 cords of slabs, trimmings, edgings, etc., of which 469,511 cords, or 25 per cent, were burned for fuel at the mills; 822,526 cords, or 44 per cent, were sold as fuel, and the remainder, 581,209 cords, or 31 per cent, were burned in the refuse burners. By using 31 per cent as the absolute waste and applying this percentage to the figures for the total production of slabs given in column 4 the estimates of the absolute waste in slabs by species, given in column 5, is obtained. The absolute waste in sawdust is estimated from the same reports as about 10 per cent of the total production, about 90 per cent being used for fuel at the sawmill. Applying this 10 per cent to column 6 the absolute waste is obtained in column 7. No part of the bark is especially utilized as such except in a few species, although some of it is used as fuel in the form of sawdust or attached to the slabs. The woods waste shown in column 9 can be considered as all absolute waste, except in the case of very few species.

The possible uses for these wastes will be discussed according to special uses applicable only to certain species or groups of species, and general uses applicable to all species.

SPECIAL USES.

All woods containing turpentine in sufficient quantities can be utilized for the production of this material by the process of steam distillation. Reports indicate that southern yellow pine is the only timber whose sawmill waste could be utilized economically by this method under present conditions, although the wastes from Douglas fir and western yellow pine contain enough turpentine, so that it may some time be profitable to utilize them in this manner. The process consists, in brief, of treating the wood (chipped or "hogged" into small pieces, if not already in a state of fine division like sawdust) in a closed steel retort with steam under some pressure, and condensing the escaping vapors which consist of steam and the volatile oils from the wood. By this process the wood fiber is not injured, and the steamed chips can be used for fuel as well as before extraction. For this reason not only the absolute waste as given in columns 5 and 7 but also the amount of wastes burned as fuel at the mills, can be utilized in this manner. According to the estimates, 25 per cent of the slabs and edgings are used as fuel at the mill, and this added to the absolute waste, 31 per cent, will give the amount of slabs which could be treated by this process, 56 per cent, or, in the case of yellow pine, 266,000,000 cubic feet, or 3,325,000 cords. Practically all sawdust is either burned in the fire box or the refuse

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burner, or allowed to accumulate in the waste pile, the amount which finds other application being negligible. The total production of sawdust from yellow pine, 303,000,000 cubic feet, or 4,600,000 cords (70 cubic feet per cord) could, therefore, be utilized by steam distillation. There are also 540,000,000 cubic feet, or 6,000,000 cords of tops, stumps, etc., from this timber, making a total of 14,600,000 cords of waste wood which could be used for the production of turpentine. The average yield of turpentine from this material would be about 2.5 gallons per cord, giving 36,500,000 gallons of steam-distilled wood turpentine, an amount greater by 6,000,000 gallons than the total production of gum turpentine in 1905. Even at the extremely low price now current for this article, 30 cents per gallon, this would mean a product with a value of $10,950,000. On computing in the same way the waste from Douglas fir and western pine which might be utilized by this process, 5,200,000 cords of the former, and 1,660,000 cords of the latter are obtained. The average yields of turpentine from this material would be for Douglas fir about one-third gallon per cord and for western pine about three-fourths gallon per cord, giving a total of 3,000,000 gallons from these two woods.

The large-sized mill and logging wastes, such as slabs, tops, and stumps, from the three species mentioned could also be used by the process of destructive distillation for the production of turpentine, tar, tar oils, and charcoal, but such a method is more especially adapted to very resinous wood, such as old stumps and "light wood," and would probably not be profitable on the average mill and logging wastes unless the most resinous portions of these materials were selected. On account of the lack of estimates on the quantity of such material available, this process will not be discussed further.

Beech, birch, and maple were used by destructive distillation for the production of wood alcohol, acetate of lime, and charcoal to the extent of 1,220,000 cords in this country in 1907. Most of the wood is cut especially for this purpose, although the use of about 60,000 cords of sawmill slabs was reported in 1907. No practicable method has yet been found for the destructive distillation of small stuff, such as shavings and sawdust; so that only large-sized waste, such as slabs, ends, tops, and limbs, could be utilized by this method. The absolute waste in slabs, trimmings, tops, stumps, etc., from beech, birch, and maple, as given in the table, amounts to 1,115,000 cords (89,000,000 cubic feet), or over 90 per cent, of the amount of hard wood used for distillation in 1907. If this waste beech, birch, and maple had been utilized, products with a value of nearly $7,000,000 would have been obtained.

Oak wood is used to some slight extent in this industry, but only when mixed with beech, birch, and maple. Oak yields on distillation, in comparison with these woods, fully as much charcoal, nearly as much acetate of lime, and about one-half as much wood alcohol. There were wasted in 1907, 2,400,000 cords of oak wood, which, if distilled, would have produced very nearly twice as much charcoal and acetate of lime, and very nearly as much wood alcohol, as was produced in hard-wood distillation plants in this country during that year.

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Hemlock, spruce, poplar, and cottonwood are at present being used in large quantities commercially as a raw material for paper making. Douglas fir, basswood, chestnut, and the various species of pine are used to a considerably smaller extent, but still can be and are successfully used for certain grades of paper.

It can be safely stated that almost any species of wood can be made into some grade of pulp, and that practically all species can be made to produce a pulp which is commercially acceptable. The economic utilization of waste wood is, however, a subject presenting some difficulties and requiring careful study. Waste wood is not in general the clear, clean wood to which pulp mills are accustomed, and often much trouble is experienced in preparing it for the digester; the knots, bark, rotten wood, and dirt must in many cases be removed, and the excessive handling in the preliminary treatment preceding the cooking process is often expensive. Waste wood of some species is, however, already being used with success (160,000 cords of slabs in 1907), especially where the pulp mills are located near sawmills. This method of utilization is therefore capable of great expansion. The utilizing of sawdust by this process has been little investigated up to the present time, but, according to some authorities, has possibilities. No final solution can at present be offered, however, and sawdust will therefore be left out of account in considering wastes that may be utilized for paper making.

If the slabs, ends, etc., which were absolute waste, and all the tops, limbs, etc., from the hemlock, spruce, poplar, and cottonwood cut for lumber in 1907 had been used for paper making, there would have been available, according to the table, 4,050,000 cords, or slightly more than the quantity of wood actually used for paper making in this country in that year. The use of yellow pine, Douglas fir, and western pine waste as mentioned does not prevent the use of the same material afterwards for paper making, since the wood fiber is not injured by the steam distillation. The only species which need be left out of the grand total which could be utilized for pulp are, therefore, beech, birch, maple, and oak, which have been considered as already utilized by destructive distillation. The total absolute waste in slabs is 450,000,000 cubic feet, or 5,600,000 cords, and in tops, stumps, etc., is 1,640,000,000 cubic feet, or 20,500,000 cords, giving a total waste of 26,100,000 cords. This amount minus 3,515,000 cords, the material already considered as utilized, leaves 22,600,000 cords, or five and one-half times as much wood as is annually used by the paper-pulp industry.

The only special use which has ever been found for large quantities of the bark of any species is as a source of tanning material. Hemlock and oak are the only barks which are now utilized for this purpose to a large extent, about 900,000 cords of the former and 380,000 cords of the latter being consumed in 1907. The total amount of hemlock bark produced as a result of the lumber cut in 1907 was, according to the table, 72,000,000 cubic feet, or about 900,000 cords, nearly all of which was utilized, since probably very little bark was cut without also using the lumber. The 380,000 cords of oak bark used in 1907 came mostly from the chestnut oak and the tanbark oak, since the bark from these species contains more tannin than from other oak. The total amount of bark from all species of

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oak cut for lumber in 1907 was 78,000,000 cubic feet, or about 970,000 cords, showing that about 590,000 cords of oak bark were unutilized. Oak wood also contains a small amount of tannin, but it is apparently not profitable at the present time to utilize this material or the bark from other oaks than tanbark and chestnut oak. In the year 1907 about 135,000,000 pounds of tanning extract from chestnut wood were used. If the absolute waste from chestnut, including all the sawdust, had been used in making tanning extract, 50,000,000 cubic feet, or 625,000 cords, of wood would have been available. At the rate of 500 pounds of extract per cord of wood this waste material would have yielded 312,500,000 pounds of extract, or more than twice as much as was used in this country in 1907. This does not indicate that half of this waste was actually utilized, because a considerable part of the extract was probably made from wood cut especially for this purpose. The use of chestnut wood for extract does not prevent the further utilization of the extracted chips for paper making, or of extracted sawdust for fuel. Other barks which contain tannin, which may be but are not utilized for production of tanning materials, are chestnut, willow, beech, birch, poplar, and spruce. Tanning materials worth $3,936,000 were imported into this country in 1907, which might have been replaced to some extent by domestic products manufactured from waste materials.

The possible profitable utilization of the leaves of conifers is apparently the last thing in the line of by-products to be thought of, and yet several years ago it was announced that the leaves of the eastern hemlock contained about 1 per cent of an oil which was composed of over 50 per cent borneol acetate, a substance which can be transformed into camphor by quite simple methods. More recently similar studies have been made on the leaves of the red cedar and Douglas fir of the Western States, with the result that volatile oils of possible commercial value have been obtained. There is a large field for investigation here, since the composition of the leaf oils of very few conifers is now known.

GENERAL USES.

In the above list of special uses there were mentioned possible methods for the utilization of all the large-sized waste, except the bark from those species which do not contain tannin in sufficient quantity to make its extraction profitable. No methods were suggested, however, for the complete utilization of the sawdust. The steam distillation of yellow pine sawdust, or the leaching of chestnut sawdust, still leaves the main woody material for further treatment. Under "General uses" will be mentioned in three divisions—(1) chemical, (2) mechanical, and (3) fuel and power—methods which are applicable to all species alike, and to sawdust as well as or even better than to larger sized material.

(1) Under general chemical methods of utilizing sawdust may be mentioned the production of oxalic acid by treating sawdust with fused caustic alkali, and the production of ethyl or grain alcohol by treating sawdust with dilute sulphuric acid and fermenting the sugar so formed. Practically no oxalic acid is manufactured in this country at present, and 7,900,000 pounds were imported in 1905.

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This process is not of much interest, however, as a method of utilizing waste sawdust, because 8,000 tons of sawdust, or only about 0.05 per cent of the total sawdust produced in this country in 1907, would make as much oxalic acid as was imported in 1905.

It is well known that ethyl or grain alcohol can be produced from wood by the general method of hydrolysis by acids with subsequent fermentation of the sugar so formed, and processes for the commercial utilization of waste wood in this manner have often been suggested. One of these processes was tried in this country a few years ago, but resulted in a failure, apparently because of difficulties in the mechanical manipulations rather than in the control of the fundamental chemical reactions. A special modification of the general method is said to be in successful operation in France, and new modifications have lately been suggested in this country which it is claimed will make successful operation possible here. Different investigators have claimed to be able to produce from 15 to 30 gallons of alcohol per ton of sawdust; at even the lower figure 19,500,000 gallons could have been produced from the sawdust which was absolutely wasted in 1907. This method is, of course, also applicable to the other classes of waste besides sawdust, except possibly the bark.

(2) Sawdust has three marked mechanical or physical properties which give it a certain commercial value. It is elastic, absorptive, and nonconducting. Various minor uses to which it has been put on account of these and other similar properties are here enumerated. These are uses applicable to the sawdust from all species.

Packing material.—The use of sawdust as a packing material for fragile articles for shipment is well known. Its value along this line is shown from the fact that it is used to pack dangerous explosives for transportation. When sawdust is well dried and free from dust, it can be used in contact with polished metal surfaces without rusting or tarnishing them.

Nonconductor.—The intermediate spaces between the joists in buildings may be filled with sawdust to make the walls more nearly "cold proof." The use of sawdust in packing ice to retard melting is well known. Sawdust with plaster of Paris or other suitable binder makes a very good material for covering steam pipes, etc., to prevent radiation of heat.

Absorbent.—Wood flour, or very finely-ground wood, is one of the best known absorbents for nitroglycerin in the manufacture of dynamite. This material is at present made in this country almost entirely from ordinary pulp wood, although in Europe it is made very largely by grinding sawdust. A large saving could be effected if this material were manufactured from a waste product, sawdust, instead of from pulp wood which could be used for other purposes. A common example of the absorptive power of sawdust is found in its use as a stable litter and in public conveyances, meat markets, etc., to keep the floors free from moisture. It also finds extensive employment in the metal industries for drying metallic articles which have been treated with acid, no other substance being so effective in drying and cleaning, and preventing subsequent oxidation such as the formation of rust or verdigris.

Porous brick.—If sawdust is mixed with the clay used in making bricks, it burns out during the treatment in the kiln and leaves the

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brick full of small cavities. These porous bricks are used instead of hollow tile in partition walls, and are claimed to be even better as a nonconductor. In the year 1900 sawdust to the value of $19,687 was used in the clay and pottery industry of the United States for this or for similar purposes.

Wood substitutes.—The utilization of sawdust as a wood substitute is ideal from the forest conservation point of view, since it makes use of a waste product of the lumber industry as a substitute for the principal product of the industry. There are many methods which have been proposed for manufacturing an artificial wood from sawdust, and some of these have been used on a commercial scale, but progress along this line has been carried further in England and France than in this country. The production of a wood substitute with the elasticity and strength of natural wood is not to be expected, but in moldings, carvings, flooring, paneling, etc., an artificial wood can be very readily substituted. The methods all consist in general of mixing the sawdust with some suitable binding material which hardens on drying or on heating, and then molding the mixture under pressure and heat, or making it into blocks or sheets as the various binders and the various requirements of the product call for. Water glass, glue, rosin, plaster of Paris, blood, casein, etc., and various mixtures of these materials are the binders used. A flooring material made of sawdust and Portland cement is used to a large extent in Germany in place of ordinary plank flooring. It is lighter and more elastic than cement alone, and gives a floor without cracks. A flooring or decking material similar to the above is found on the European markets. This material has been used on the lower and second-class cabin decks of many trans-Atlantic vessels with excellent results. Although materials of this kind have not been extensively used in this country, it is known that wood flour or finely ground sawdust has been used to some extent in flooring, such as linoleum substitutes, and its use as a substitute for the ground cork in linoleum itself has also been reported.

In these various applications of the peculiar physical properties of sawdust there are many possibilities for an expansion of its present use.

Fuel and power.—Probably the one largest use to which sawdust is put in this country is as fuel, but this is almost entirely confined to the immediate plant in which it is produced. Special fire boxes and grates are required, and it is never so satisfactory as larger-sized wood. It is also so bulky that its transportation away from the plant is not economical. It may be stated in this connection that the full fuel value of sawdust is seldom developed under present conditions, mainly because the mills burning it have a very plentiful supply and need not economize. If, therefore, it became necessary or profitable to economize in this respect, much less sawdust could be used with the same results. A method has been suggested for making sawdust more readily transportable and at the same time making it a more satisfactory fuel by pressing it with or without a binding material into briquettes. This method is not profitable in this country on account of the other cheap fuels nearly everywhere available, and on account of the cost of briquetting. As fuel becomes scarcer, however, this plan will become more practicable.

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The method by which sawdust can be most economically transformed into power is probably by means of the gas producer and the gas engine, gas producers now being on the market which are claimed to make a gas as consistent in composition and as satisfactory for gas engines as any producer gas made from other materials. The possibilities for the transportation in the form of electrical energy of the power obtained from sawdust through the use of the gas producer and gas engine seem to be greater than for the transportation of the sawdust, either loose or in the form of briquettes.

SECONDARY WASTE.

In 1907, 2,059,496 cords of wood were made into paper pulp by the sulphite process. About 1,030,000 tons of pulp were made from this wood, the remainder, about half the total amount by weight, being left combined with the chemicals used in the form of "waste sulphite liquor." This substance has been investigated by many experimenters in an endeavor to find some method for its utilization. Its uses as a briquette binder, dust layer, sizing for paper, and tanning material have been suggested, but none of these methods have up to the present time attained any commercial prominence. The large amount of this waste material available, however, and the information which has already been obtained regarding its properties surely warrant further investigation.

Pyroligneous acid from pine-wood distillation.—In the year 1907, 61,149 cords of pine wood were distilled in the United States. Probably 45 per cent of this wood, 27,518 cords, was distilled by the destructive process, one of the products of which, pyroligneous acid, is almost entirely wasted. This pyroligneous acid contains wood alcohol and acetic acid, and if these two products were recovered the yield would be about 3 gallons of 82-per-cent alcohol and 50 pounds acetate of lime per cord of wood; 82,554 gallons of wood alcohol and 1,400,000 pounds of acetate of lime were therefore wasted in 1907. The recovery of the materials has never been successful on a commercial scale in this country, although in Germany they are considered valuable products of the process and are saved.

Turpentine from dry kilns.—Probably 30 per cent of the cut of yellow pine for 1907, or 3,964,555,000 board feet, was treated in dry kilns; probably 1 gallon of turpentine on an average was removed from every thousand feet so treated, and none of it was recovered; nearly 4,000,000 gallons were therefore wasted. A process of kiln drying has lately been proposed which claims to remove practically all the turpentine from resinous wood and at the same time to dry the wood quicker and better. If these claims are true there could be recovered probably 3 gallons of turpentine from every thousand feet of southern yellow-pine lumber dried, and there could have been produced in 1907 from the dry kilns an amount of turpentine more than one-third of the total production of gum turpentine in 1905. The complete removal of turpentine from the lumber of resinous woods improves the quality of the lumber, and rapid removal of turpentine vapors from dry kilns tends to reduce the fire risk. On account of these facts, it seems that a process for the recovery of turpentine from dry kilns can be made an economical proposition.

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THE DIFFICULTIES.

In the necessarily limited amount of space occupied by the preceding chapters, it has been impossible to treat the subject with which we are dealing with all the detail which might be desired. The most that has been attempted has been to give approximations of the enormous quantity of annual waste, and to suggest some of the possible methods of utilizing it. In attempting to put any of these or other methods into effect, many difficulties are liable to arise, and any attempt here to classify these methods and point out the specific difficulties in employing each or the specific remedies for these difficulties would mean to occupy more time and space than can be had, and would further limit our view of the whole subject. At present it is necessary for a thorough understanding to obtain the broadest possible survey of the mighty task which this nation has before it. The chief difficulty seems to be a general lack of knowledge, not only of the materials to be saved and the products which can be derived from them, but of what has been done in foreign countries along these lines, and of industrial conditions at home—both local and national—which have a bearing on the subject. If more were known concerning the materials to be treated, it would be easier to suggest methods of utilization; if a better knowledge were had of the successes which had been achieved in foreign countries, and of the industrial conditions at home, it would be less difficult to pick out the methods most likely of success in this country. In a sense, there are already available many miscellaneous facts which are of great value, and it is possible to suggest at the outset methods, which, if employed, would lead to greatly improved conditions in the utilization of wood waste, but the employment of all these methods to their full economic value would save but a small portion of the vast quantity of waste. What is needed is more information. At present such as there may be is very scattered, and no one organization is in possession of all the facts or is making an extensive, systematic study of the subject.

In spite of the examples set by sister industries in the utilization of waste and the successes which have been reached, the subject of waste wood has in this country receives scant attention on the part of those immediately concerned. The reason seems to be that while prosperous business conditions prevail, private firms consider themselves too busy to make a careful study of the subject, and can see no immediate necessity for such an investigation; and in times of business depression they do not feel like making the necessary expenditure. In this connection it may also be stated that while the expense would not be greater than some corporations could readily afford, still for the great majority of firms a satisfactory investigation would greatly diminish the profits, and it is doubtful if the quantity of waste which the latter have at their disposal would be sufficient to warrant making the extensive investigation which might be necessary for a solution of the problem. Any investigation of this kind on the part of a small company is usually very limited in its scope instead of being a sound, scientific investigation of the whole subject. Further, industries which have already obtained a footing and might readily utilize wood waste with good profits under proper management remain for years in an unprogressive

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attitude toward this subject, when the proper application of capital and brains might lead to great developments.

HOW TO ATTACK THE PROBLEM.

First of all it is necessary to collect under one organization all of the available information bearing on the subject, both in this country and in foreign countries, and hold it in such form and place that it can be readily referred to at an instant's notice. This organization should keep in touch with all new developments along this line, and should not only distribute reliable information upon application, but should also actively bring to the attention of the proper persons the necessity of utilizing wood waste and the best methods to employ. Thorough cooperation should be had not only with the scientific men of the country, but also with the practical men of the industries. As many phases of the subject as possible should be studied at the same time, and in close cooperation with each other, and this could best be accomplished by having the work done entirely under one organization. Further, the spirit of this organization should continually be that expressed by the great French writer:

> The human race could increase its welfare almost as much by a better ordering of its consumption as by an increased production of wealth, and this without any retrenchment in consumption.

Certain classes of information can only be obtained by experimentation, and for this reason the organization should be provided with a thoroughly equipped laboratory for carrying on experimental work. The true value of many of the various processes could thus be shown, valuable old ones improved, and new ones suggested. Uses for new products and new uses for old ones could also be discovered, and infant industries in this way would be greatly aided. It may seem logical that the people who have waste wood to dispose of are the proper ones to undertake such experimental work and investigation, but there are many reasons why this is not so and why it is more advisable to have such work done by a central organization. Some of these reasons have already been expressed in the preceding chapter, and in addition it may be said that the results obtained from experiments of private firms would not be available for the use of others, and the good effects would therefore not be widespread. A government organization placed under the supervision of the Forest Service and provided with sufficient funds so that it could operate independently of cooperative money would be an ideal institution for carrying on this work. The ability of the Government to collect certain classes of information is greater than that of private firms, and there is an added advantage that the investigations would be known to be impartial and disinterested and would have the confidence of all concerned; and further, being under the Forest Service, which organization is constantly in touch with those most concerned, the work could be readily carried on in hearty cooperation with all interested parties. The solution of the problem will require time and patience and an organization of more or less permanence, but in the end the results obtained will amply justify a liberal expenditure.

In conclusion, it may be stated that the facts as already known firmly warrant further and more elaborate investigation, and it is earnestly hoped that in the near future an opportunity for making such an investigation will be forthcoming.

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WOOD PRESERVATION.

By W. F. Sherfesee and H. F. Weiss,
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INTRODUCTION.

Wood preservation began in the United States on a commercial scale in 1848, when Mr. James B. Francis, C. E., established a kyanizing plant at Lowell, Mass. This plant is still in operation, although the amount of timber treated in it is comparatively small. About 1874 a creosote-impregnating plant was established at West Pascagoula, Miss. This was one of the first plants of its kind erected in this country and is still in active operation. Since then a number of others have been installed, the most rapid development being along the Gulf of Mexico. The gradual depletion of the timber supply, resulting in an increase in the price of the raw product, has more recently fostered the growth of wood-preserving plants, especially throughout the central and eastern United States. The ravages of shipworms have been primarily responsible for the installation of the plants on the Atlantic, Gulf, and Pacific coasts. In 1904 the total annual output of treated timber in the United States was approximately 500,000,000 feet b. m. In 1907 the number of plants had increased to 60, with a total annual output of approximately 1,250,000,000 feet b. m. New plants are being erected from time to time, and it is reasonable to expect that they will increase considerably in number and capacity.

Creosote is the most common preservative used, although a large amount of zinc chlorid is employed in the treatment of ties for the central western railroads. Experiments are now being carried on by the Santa Fe Railroad Company in treating ties with crude oil. If these prove successful the growth of wood preservation in the West will be very rapid. The high freight rates now existing in the Rocky Mountain States, coupled with the eastern localization of creosote production, have prevented a more rapid expansion of wood preservation in the West. The Forest Service is carrying on a number of experiments in which zinc chlorid is used in combination with crude petroleum. If these or similar experiments prove successful they will result in greatly alleviating this condition.

FACTORS INVOLVED IN THE PRESERVATION OF WOOD.

The preservative treatment of timber by chemical and mechanical means permits its more economical utilization by decreasing destruction due to decay, fire, marine borers, insects, and mechanical abrasion.

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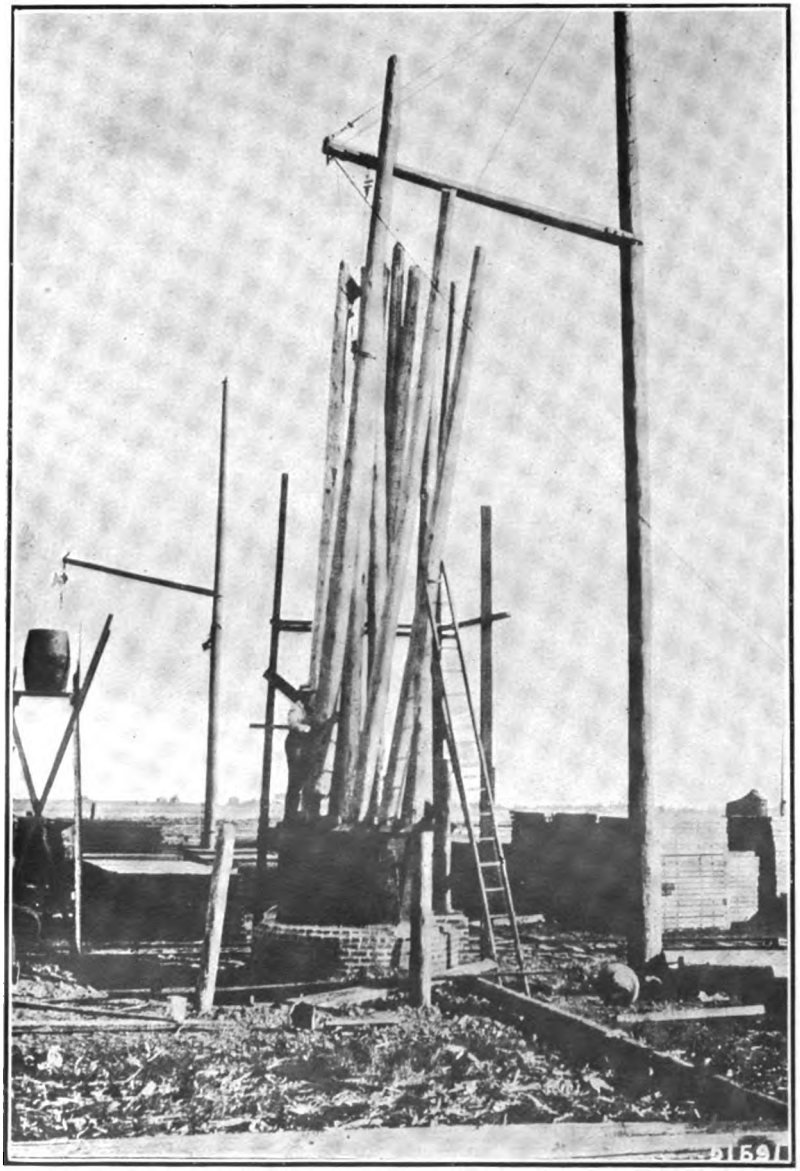

GENERAL VIEW OF TIMBER-TREATING PLANT.

(Partial submersion.)

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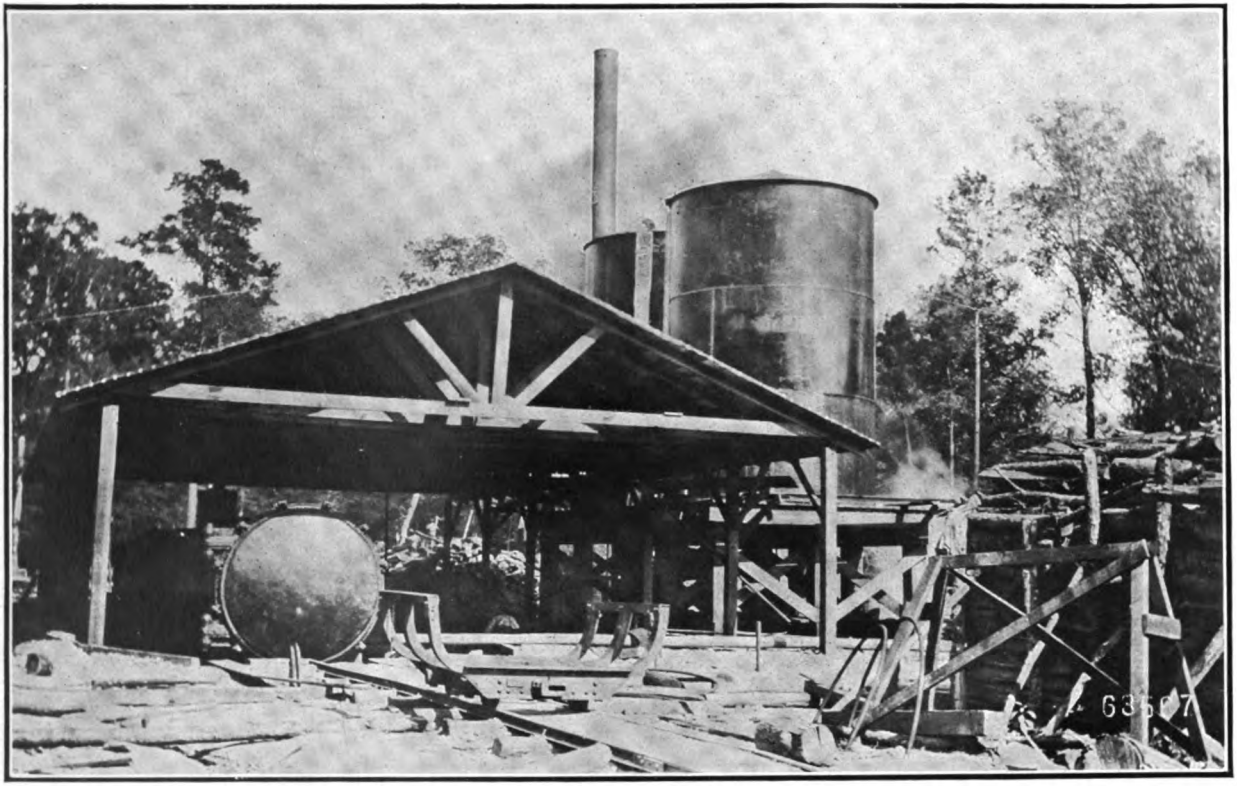

GENERAL VIEW OF TIMBER-TREATING PLANT.

(Entire submersion of wood.)

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Decay is by far the most serious agency, and affects most timber in contact with the atmosphere, soil, or water. Preservative methods are concerned, therefore, chiefly in protecting timber from this kind of destruction.

An enormous amount of timber is annually destroyed in the United States by fire. The fire loss in buildings in the United States amounts to about $251,000,000 per year. It is particularly desirable that this loss should be decreased, because it is usually accompanied by a corresponding loss of other commodities, and even of life itself. In the larger cities the substitution of materials for wood has tended to decrease the fire loss, but far greater protection can be rendered in the way of impregnating wooden floors, door casings, roofs, etc., with fire-resisting chemicals. Even if the chemicals do not succeed in absolutely checking the fire, its progress can be retarded to such an extent as to render difficult its gaining much headway.

The rapidity with which timber is destroyed by marine borers and the necessity for frequent replacements necessitates a large consumption for such purposes. The fact that thoroughly sound piling is often completely destroyed within a month shows the importance of protection and the wide field for its application. The activities of marine borers extend along both of our coast lines and as far north as Alaska. Next to decay and fire the destruction they cause is of the the greatest importance in the preservation of timber.

Insects are responsible for the destruction of a large amount of cut timber each year in the United States. The loss is caused by their boring into the wood and thus fostering conditions for the growth and propagation of wood-destroying fungi.

The destruction of timber by abrasion is largely confined to railroad ties, fender piles, and mine props. The substitution of steel for wood in cars has very greatly decreased the loss due to this cause.

The following commodities should be given preservative treatment, which would result in a financial saving, as well as a more economic utilization of forest products: Railroad ties, poles, mine props, shingles, lumber, posts, and piling.

THE ANNUAL DESTRUCTION OF TIMBER DUE TO DECAY, FIRE, INSECTS, MARINE BORERS, AND MECHANICAL ABRASION.

This information can be best given by a compact table. Table I shows the estimated annual destruction of timber for each class of material adapted to preservative treatment according to each specific destructive agency. The figures are based on the same unit (b. m.) and are only approximations.

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TABLE 1.—*Estimated annual destruction of cut timber in United States which can be eliminated or reduced by proper treatment (thousand feet b. m.)*

Class.	Total annual replacements.	Decay.		Fire.		Insects.		Marine borers.		Abrasion.	
		Amount.	Per cent.	Amount.	Per cent	Amount.	Per cent.	Amount.	Per cent.	Amount.	Per cent.
Ties	3,300,000	2,871,000	a87	.....	.....	16,500	½	.....	.....	412,500	12½
Poles	147,720	140,334	95	.....	.....	5,909	4	.....	.....	1,477	1
Posts	3,000,000	2,700,000	90	165,000	5½	120,000	4	.....	.....	15,000	½
Mine props	402,000	281,400	70	2,010	½	38,190	9½	.....	.....	80,400	20
Piles	191,520	9,576	5	.....	.....	.....	.....	181,944	95	.....	.....
Shingles	1,100	1,045	95	55	5	.....	.....	.....	.....	.....	.....
Lumber	2,625,000	1,863,750	71	131,250	5	315,000	12	52,500	2	262,500	10
Total	9,667,340	7,867,105	.....	298,315	.....	495,598	.....	234,444	.....	771,877	.....

a This figure includes destruction due to fire as well as to decay.

The annual replacements of each class are found by dividing the total amount of timber in use by the estimated average life of the untreated timber.

EFFECT OF DETERIORATION IN THE QUALITY OF TIMBER UPON THE AMOUNT USED.

Table 1 shows the annual destruction of timber due to the five agencies mentioned. It is well known that the quality of timber is deteriorating each year, so much so, in many respects, that it has caused a complete revision of the specifications for grading it. This is due mostly to the exhaustion of the better grades, which has forced the utilization of the poorer qualities. Thus, where specifications once rigidly insisted upon first quality white oak for ties, or heart longleaf pine for dimension stuff, they are now given a very liberal interpretation, and species other than white oak are accepted with no difference in price, or considerable amounts of sapwood are allowed on "all-heart" sticks.

This deterioration in quality naturally results in a decreased length of life, which in turn compels a larger annual cut of timber. Hence, the amounts given in Table 1 will increase year by year in direct proportion to the decrease in quality.

HOW WOOD PRESERVATION WOULD LESSEN THE DRAIN ON THE FORESTS.

That the drain on the forests of the country would be materially reduced by a proper preservative treatment of all structural timbers can not be doubted. It is very evident that by prolonging the life of timber a given number of years the amount cut for replacements would be correspondingly reduced. Table 2 shows this very conclusively. It is seen that if all ties, poles, posts, piling, mine props, shingles, and structural lumber adapted to treatment were given a proper treatment an annual saving of about 6,000,000,000 feet b. m. would ensue.

It is a well-established fact that a proper preservative treatment will prolong the life of the decay-resisting species as well as that of an inferior grade. By applying this treatment, it is evident that a reduction in the annual cut for replacements will follow, but since

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UNTREATED AND TREATED MINE PROPS AFTER EIGHTEEN MONTHS' SERVICE.

The untreated stick has been weakened by decay and broken.

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the increase over the natural life is larger with inferior grades, better financial results will be obtained by their use. The different species of wood, such as cedar, cypress, white oak, etc., which are naturally resistant to decay, have in former years been used to a very great extent. In consequence of this quality, the supply of these species is very rapidly diminishing, and the consumers are of necessity turning their attention to other species formerly largely disregarded on account of their inability to resist decay. The increasing demand for loblolly pine in the South and the lodgepole pine and Engelmann spruce in the West are examples. If these species are used in an untreated condition, they will decay far more rapidly than the timber formerly employed, and a consequent increased annual cut will ensue. Hence, it is essential that they be given a preservative treatment.

To sum up, wood preservation not only prolongs the life of durable timbers, thus decreasing their annual consumption, but also permits the substitution of inferior species, whose use considerably reduces the drain upon the more valuable kinds.

TABLE 2.—*Estimated reduction in annual cut which would ensue from a proper preservative treatment of all timber.*

Class.	Estimated average life, in years.		Estimated annual replacement—all species.		Estimated saving in annual cut (actual quantity).	Board measure equivalent (1,000 feet b. m.).
	Untreated.	Treated.	Untreated.	Treated.		
Ties	7	17	100,000,000	41,200,000	58,800,000	1,940,000
Poles[a]	13	23½	2,462,000	1,380,000	1,082,000	64,920
Posts	8	22	500,000,000	180,000,000	320,000,000	1,900,000
Piles	3½	21½	1,140,000	190,000	950,000	159,600
Mine props	3	13	[b] 67,000,000	[b] 15,300,000	[b] 51,700,000	310,200
Shingles	18	32	[c] 1,100,000	[c] 625,000	[c] 475,000	475
Lumber	8	20	[c] 2,625,000,000	[c] 1,050,000,000	[c] 1,575,000,000	1,575,000
Total						5,950,195

[a] No allowance is made for the fact that the greater percentage of poles now being treated are of so-called "inferior species". When properly treated they will have their natural life increased by more than the general average of 10.25. Hence, by a greater use of these species, there will ensue a corresponding reduction in the annual cut.

[b] Cubic feet.

[c] Feet board measure.

HOW WOOD PRESERVATION WOULD PERMIT SIMPLER AND MORE PROFITABLE SYSTEMS OF FOREST MANAGEMENT.

It has been pointed out that wood preservation brings into use the inferior qualities of timber, thus decreasing the drain upon those species of greater value. It should be noted that these so-called "inferior species" are often rapid growers and prolific seeders. Moreover, as a rule, they possess the requisite adaptability to environment which enables them to persist through a wide range of conditions, even under unfavorable circumstances. Their rapid growth produces a larger volume of wood, and quicker and larger financial returns.

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TABLE 3.—*Comparison of loblolly and longleaf pine from the standpoint of wood preservation and forest management.*

	Loblolly.	Longleaf.
Germinating percentage of seed	50 to 80	50 to 70.
Frequency of seed years	1 year	3 or 4 years.
Artificial reproduction	Easy	Hard to handle on account of long tap-root.
Natural reproduction	Good, because of its tolerance and rapid growth. It frequently comes in and drives out the longleaf. Lightness of seed allows wider distribution.	Poor because rare occurrence of seed years allows other species to get the lead. Its slow growth and intolerance cause it to be readily killed back.
Soil requirements	Will not grow in extremely dry soils. Prefers moister situations.	Less exacting; will grow on dry sandy soil.
Rate of growth	Very rapid. 12 inches diameter breast-high at 50 years.	Slow. 8 inches diameter breast-high at 50 years.
Yield per acre	Rotation, 70 years; diameter breast-high, 18 inches; yield, 33,000 feet b. m.	Rotation, 120 years; diameter breast-high, 18 inches; yield 25,000 feet b. m.
Cost of crops per acre (value land, $10;[a] taxes, 3 cents per year; fire protection, 2 cents per year; interest, 4 per cent).	$174	$1,244.
Estimated future value of crop per acre (loblolly, $8 per M board measure; longleaf, $13 per M board measure).	$264	$325.
Total profit or deficit	$90	$919.
Shipping weight, (pounds per M board measure).	3,000	3,500.
Adaptability to treatment	Adapted	Not adapted.

[a] Includes cost of reforesting.

It can be seen from Table 3 that the growth and cultivation of loblolly pine forests result in an annual profit of about $9 per acre more than for longleaf. It must not be construed, however, that this implies the total substitution of loblolly for longleaf, or, abstractly, the substitution of inferior for superior species. Sylvical factors often prevent this, but the fact remains that longleaf pine can not be grown at a financial profit under the conditions outlined in the table.

Many similar examples could be cited showing how a forest composed of the so-called "inferior species" would prove a better investment than one composed of the more valuable varieties. In other words, it is frequently better policy to cultivate rapid-growing trees for ties, posts, poles, piles, etc., and treat them, rather than grow those trees which are naturally durable and which take a long time to mature.

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CREOSOTED YELLOW PINE POLE, SOUND AFTER EIGHTEEN YEARS' SERVICE.

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INCREASED LIFE AFFORDED BY PROPER PRESERVATIVE TREATMENT.

The increased life afforded by proper preservative treatment is shown in detail for each class of material listed according to species in Tables 4 to 10, inclusive.

TABLE 4.—*Ties.*

Species.	Estimated average number years untreated life.	Estimated average number years treated life.	Species.	Estimated average number years untreated life.	Estimated average number years treated life.
Cedar	11	20	Post and burr oak	7	15
Cypress	10	20	Birch	5	15
Redwood	12	20	Beech	5	20
Chestnut	7½	15	Hemlock	5	15
White oak	8	20	Longleaf pine	7	20
Tamarack	6	15	Maple	5	15
Spruce	6	14	Black oak	4	15
Red fir	7	15			

TABLE 5.—*Poles.*

Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.	Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.
Cedar	12–15	25	Juniper	10–13	25
Chestnut	8–10	20	Redwood	12–15	30
Lodgepole pine	5	20	White oak	8	20
Western yellow pine	6	25	Douglas fir	8	20
Cypress	12	25			

The best available figures on the life of creosoted poles are from the German postal and telegraph department, which after 52 years of observation gives life of twenty-one years for creosoted Baltic pine poles.

TABLE 6.—*Posts.*

Species.	Estimated number of years untreated life.	Estimated number of years treated life.	Species.	Estimated number of years untreated life.	Estimated number of years treated life.
Cedar	12	25	Redwood	14	25
Juniper	15	25	White oak	8	20
Cypress	12	25	Red oak	5	20
Locust	20	30	Tamarack	5	20
Catalpa	14	20	Chestnut	10	20
Longleaf pine	8	20	Osage orange	20	30
Douglas fir	7	20			

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TABLE 7.—*Piles in warm salt water.*

Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.	Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.
Longleaf pine	2-3	35	White oak	2-3	(c)
Shortleaf pine	2-3	40	Red oak	2-3	35
Loblolly pine	2-3	40	Cedar	2-3	20
Douglas fir	2-3	20	Cypress	2-3	20
Spruce	a 8	(b)	Eucalyptus	2-3	(c)
Redwood	2-3	20			

a Years untreated life applies if placed in cold water. b No records. c Not treated.

NOTE.—Red-pine piles creosoted served 46 years. (Clyde Nav. Trust—Glasgow.)

TABLE 8.—*Mine props.*

Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.	Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.
White oak	5	15	Aspen	2	15
Red oak	3	15	Maple	3	10
Fir	5	12	Hickory	3	10
Hemlock	5	10	Shortleaf pine	3	15
Chestnut	5	12	Tamarack	5	10
Spruce	3	10	White and yellow pine	5	15
Beech	3	15			

NOTE.—The foregoing estimates have been formed without any allowance for the effect of crushing

TABLE 9.—*Shingles.*

Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.	Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.
Cedar	20	35	Yellow pine	10	20
Cypress	18	30	White pine	15	25
Redwood	18	30	Chestnut	10	20

NOTE.—The figures quoted above are only approximations, as there are no available data on the life of shingles.

TABLE 10.—*Lumber set subject to decay.*

Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.	Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.
Yellow pine	8	20	Red gum	4	10
Douglas fir	10	20	Beech a	4	20
Oak	8	20	Birch	5	12
Hemlock	6	17	Basswood	4	20
Spruce	6	17	Cottonwood	4	25
Bull pine	6	20	Elm	7	12
Chestnut	12	20	Ash	5	10
Redwood	14	25	Larch	6	15
White pine	8	20	Sugar pine	6	18
Maple	5	16	Tupelo	4	25
Poplar	4	25	Sycamore	3	25
Cypress	14	22			

a "White heart."

NOTE.—In this table mechanical wear is neglected and decay alone considered, and this only in lumber placed subject to decay. This does not include doors, furniture, stairs, etc.

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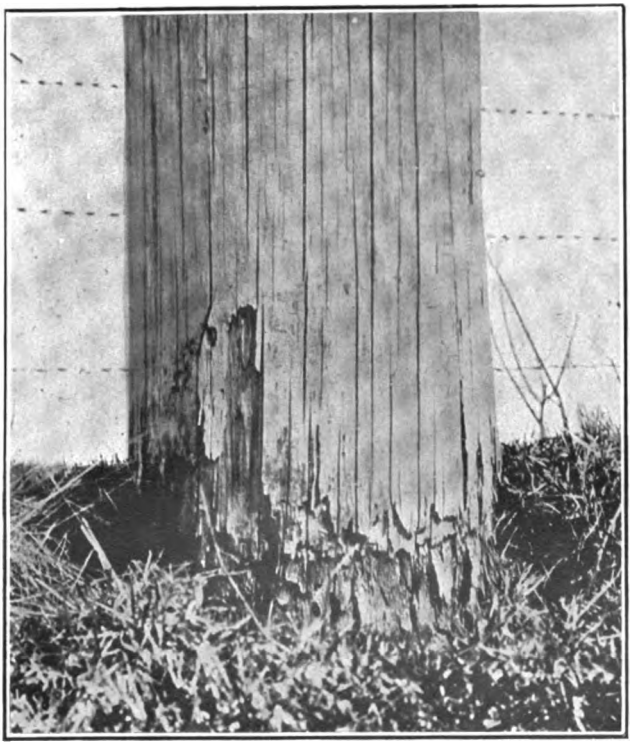

CHESTNUT POLE, DECAYED AFTER SIX YEARS' SERVICE.

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THE FINANCIAL SAVING RESULTING FROM THE PRESERVATION OF TIMBER.

The financial saving that would result each year in the United States, were a uniform policy of treating timber adopted, is shown for each class and in sum total in Table 11. The total annual saving would amount to about $72,000,000. It should be remembered that this includes the cost of labor as well as that of the timber itself, and thus represents the amount of money that could be turned each year into other channels.

TABLE 11.—*Estimated annual financial saving by proper preservative treatment.*

Class.	Cost.			Cost of treatment.	Years of life.	
	Material.	Placement.	Total.		Untreated.	Treated.
Ties	$0.47	$0.20	$0.67	$0.35	7	17
Poles	4.00	3.00	7.00	1.50	13	23½
Posts	.10	.10	.20	.12	8	22
Piling[a]	.10	.05	.15	.25	3½	21½
Mine props[a]	.045	.23	.275	.11	3	13
Lumber[b]	16.50	2.00	18.5	10.0	8	20

Class.	Annual charge.		Annual saving.	Quantity in use.	Total amount saving.
	Untreated.	Treated.			
Ties	$0.12	$0.097	$0.023	700,000,000	$16,100,000
Poles	.78	.69	.09	32,000,000	2,880,000
Posts	.032	.026	.006	4,000,000,000	24,000,000
Piling[a]	.050	.034	.016	4,000,000	1,800,000
Mine props[a]	.10	.04	.06	200,000,000	12,000,000
Lumber[b]	2.98	2.48	.50	[c]30,000,000	15,000,000
Total					71,780,000

[a] Charges per cubic foot.
[b] Charges per M feet board measure.
[c] Refers only to that adopted to treatment.

NOTE.—The initial cost is taken at the point of purchase, no allowance being made for freight charges.

THE SUBSTITUTION OF MATERIALS FOR WOOD.

In considering the substitution of materials for wood, the use of steel and concrete, both separately and in combination, has undoubtedly far exceeded that of all other materials. When one considers the vast quantity of reenforced concrete now used for all kinds of building and construction purposes, the amount of steel used for towers and poles in electric transmission lines, the number of steel and concrete piles and bridges, and the growing popularity of steel for the construction of railroad cars (which are only a few of the many ways in which these materials have been successfully utilized), it can be seen that the reduction upon the annual demand for structural timbers is considerable, and that the substitution of these and other materials is bound to increase from year to year. Engineers are continually experimenting with different materials with this end in view. Striking examples are the experiments being so widely carried on with steel and concrete railroad ties. Reports from 53 rail-

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roads show varied results with such ties during the past few years, but the fact that so many railroads are experimenting along these lines shows conclusively that the importance of the substitution of some material for wood is realized, and there is no reasonable doubt but that in the future some such substitution will be accomplished. Experiments that have been carried on with glass for use in poles are other examples of this tendency.

In substituting inorganic materials for wood, the limited supply of the materials must be kept in mind. Iron, for example, when once taken from the mine, is gone; it can not be renewed. Wood, on the other hand, is capable of growth, and hence of indefinite replenishment of supply from the same area. This fact will cause metals to rise in value, so that the ratio of cost between them and wood for construction purposes will be an ever changing one.

In the manufacture of coal cars, buildings, boats, etc., the substitution of metal for wood has passed the experimental stage. Uncertainly of successful substitution exists at present for ties, poles, piles, light cars and other vehicles, but the large number of experiments that are being carried on promise that here, too, in a large measure, wood will be supplanted. In 1904 the Carnegie Steel Company sold to the trade 11,329 steel railroad ties, and 572,233 in 1907. This company claims that the steel tie is no longer an experiment. The general impression throughout the country, however, is that considerable experimenting must be done before a satisfactory substitute for the wooden tie is found.

No estimate in figures can be given as to the effect the substitution of these and other less popular materials have or will have with regard to the reduction of the annual demand for structural timber. It is too vast for estimation, but it is important that substitutes be used wherever possible, since the available supply of timber is none too large to meet the requirements of industries which of necessity must utilize wood.

CONCLUSION.

Wood preservation began on a commercial scale in the United States in 1848. There are at the present time about 60 plants in operation, with a total output of approximately 1,250,000,000 feet b. m. Most of these plants are located in the South, East, and Central West, but the tendency will be to extend westward as the supply of timber gradually decreases.

The preservation of cut timber reduces its destruction by decay, fire, insects, marine borers, and mechanical abrasion. These factors destroy annually about 9,700,000,000 feet b. m. of cut timber in the United States. Decay is by far the most destructive agency; its retardation, therefore, is of prime importance.

On account of the rapid depletion of standing timber, grades of poor quality are now being sold in the market. This has resulted in more timber being cut each year to do the same work that a smaller amount of the better grades did a few years ago.

Wood preservation, then, accomplishes three great economic objects: (1) It prolongs the life of the durable species in use; (2) it prolongs the life of the inferior and cheaper woods; and (3) it permits the utilization of inferior woods which without preservative treatment would have little or no value.

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Quite frequently inferior woods are rapid and prolific growers, and sprout up on cut or burned over areas in such numbers and with such persistence that the slower growing and the naturally more valuable kinds are hopelessly outstripped. Such restocked land has heretofore represented almost a total economic loss, because of the little value of the new crop. Wood preservation has changed this aspect. It has allowed these cheap woods to be utilized, and by so doing has decreased the call for skilled labor necessary to properly manage forests, and increased the revenue that can be derived therefrom.

Other things being equal, the increased life afforded by proper preservative treatment varies directly with the use to which the treated timber is put. Estimates on the increased life of various kinds and forms of timber are approximately as follows: Ties, 10 years; poles, 10¼ years; posts, 14 years; piles, 18 years; mine props, 10 years; shingles, 14 years; lumber, 12 years.

The increased length of life as a result of preservative treatment decreases the annual cut of timber in direct proportion to the increase secured. Table 2 shows that the total estimated saving would amount each year to approximately 6,000,000,000 feet b. m., or about 12 per cent of the total lumber cut. The saving of our timber resources, therefore, is strikingly apparent.

But still further, this saving in material wealth can be brought about by a corresponding financial saving in the cost of maintenance, thereby permitting current expenditures to be placed in other channels. In table 11 the total estimated saving that would accrue as a result of a uniform policy of wood preservation approximates $72,000,000 a year. This estimate includes timber set in position; hence the labor cost of placement is included. Thus it is not only possible to reduce the amount of lumber cut 12 per cent, but to do it at an annual saving of $72,000,000.

The substitution of materials for wood has met with greatest success in heavy construction. Steel and concrete are in most general use, and from the large number of experiments that are being carried on it seems reasonably certain that the field of successful substitution will gradually increase. This will result in very materially decreasing the drain on the forests, but just how much can not be predicted.

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FOREST PLANTING.

By A. S. Peck,
United States Forest Service.

INTRODUCTION.

From reports received and compiled by the Forest Service it is estimated that 39,500,000 acres of the forest area of the United States must eventually be restocked by artificial means if this area is to be placed on the highest commercially productive basis. In addition, it is estimated that for the best interests of agriculture a total of 16,500,000 acres of naturally treeless land should be forested in the prairie region and on the irrigated land in the West, making a grand total of 56,000,000 acres. (See Tables 1 to 6.) A beginning in this work has scarcely been made, for the total area of planted timber in the United States amounts only to 962,927 acres, less than 2 per cent of what is needed.

For the purpose of discussing planting, the United States may be divided into an eastern, a central treeless, and a western region. (See fig. 1.)

EASTERN REGION.

This region includes all the country east of the prairie States, comprising the original hard-wood area of the East and the northern and southern coniferous forests. Of the two main purposes of forest planting, commercial and protective, the former is of chief importance in the East. This includes both the growing of timber and the production of material for special purposes. The classes of land which offer opportunities for planting are:

(1) Cut-over and burned-over lands, not fitted for agriculture, which are not restocking naturally with commercially valuable trees.

(2) Forest lands originally cleared for agriculture, which have since proven unsuitable for this purpose.

(3) Farm wood lots.

The most extensive areas of the first class consist of tracts of burned land in the spruce forests of the Northeast and the waste pine lands of the Lake States. Limited areas requiring reforestation occur in southern forests.

The most striking examples of the second class are to be found in the abandoned farms and waste lands of southern New England and the cleared lands of the southern Appalachians, damaged by erosion.

Throughout the hard-wood region generally, wood lots have deteriorated to such an extent that planting is necessary to restore them

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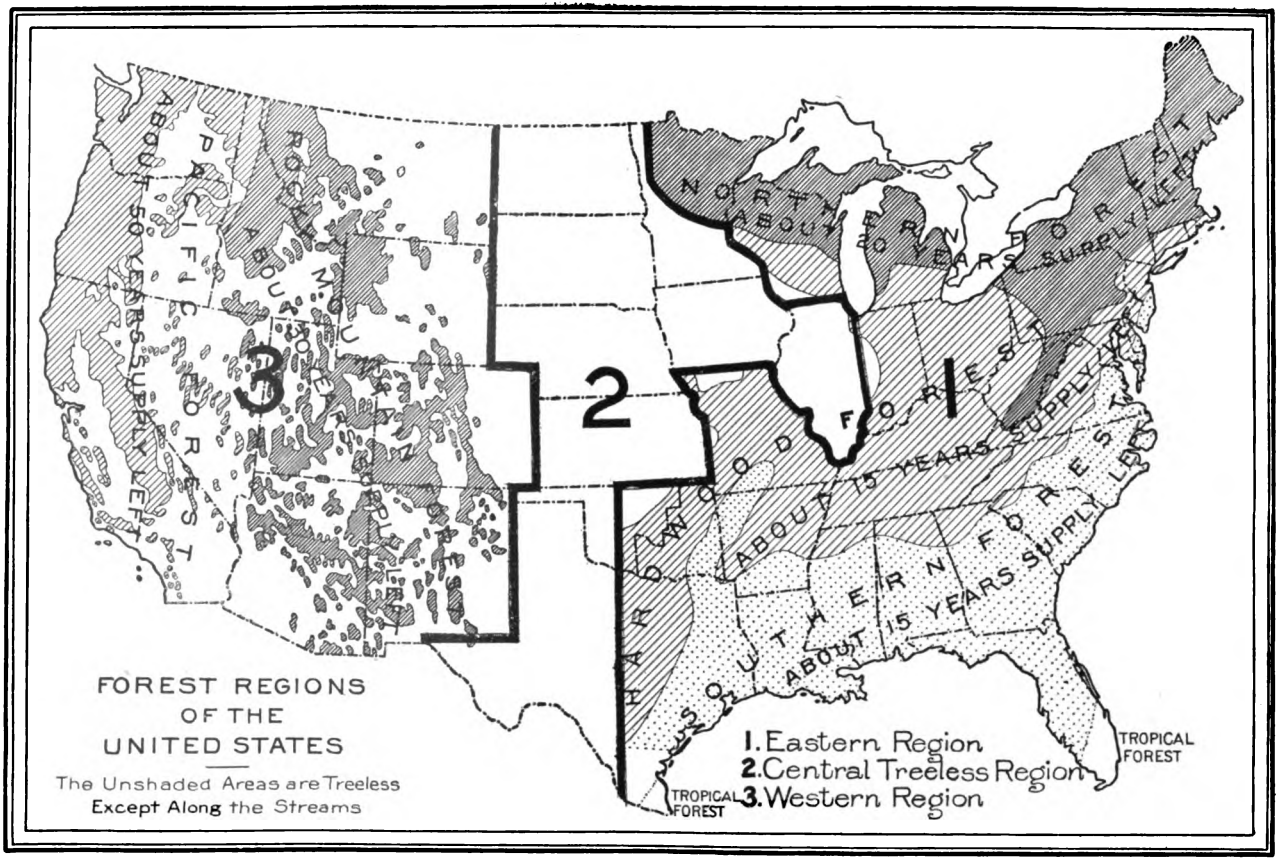

FIG. 1.—FOREST PLANTING REGIONS.

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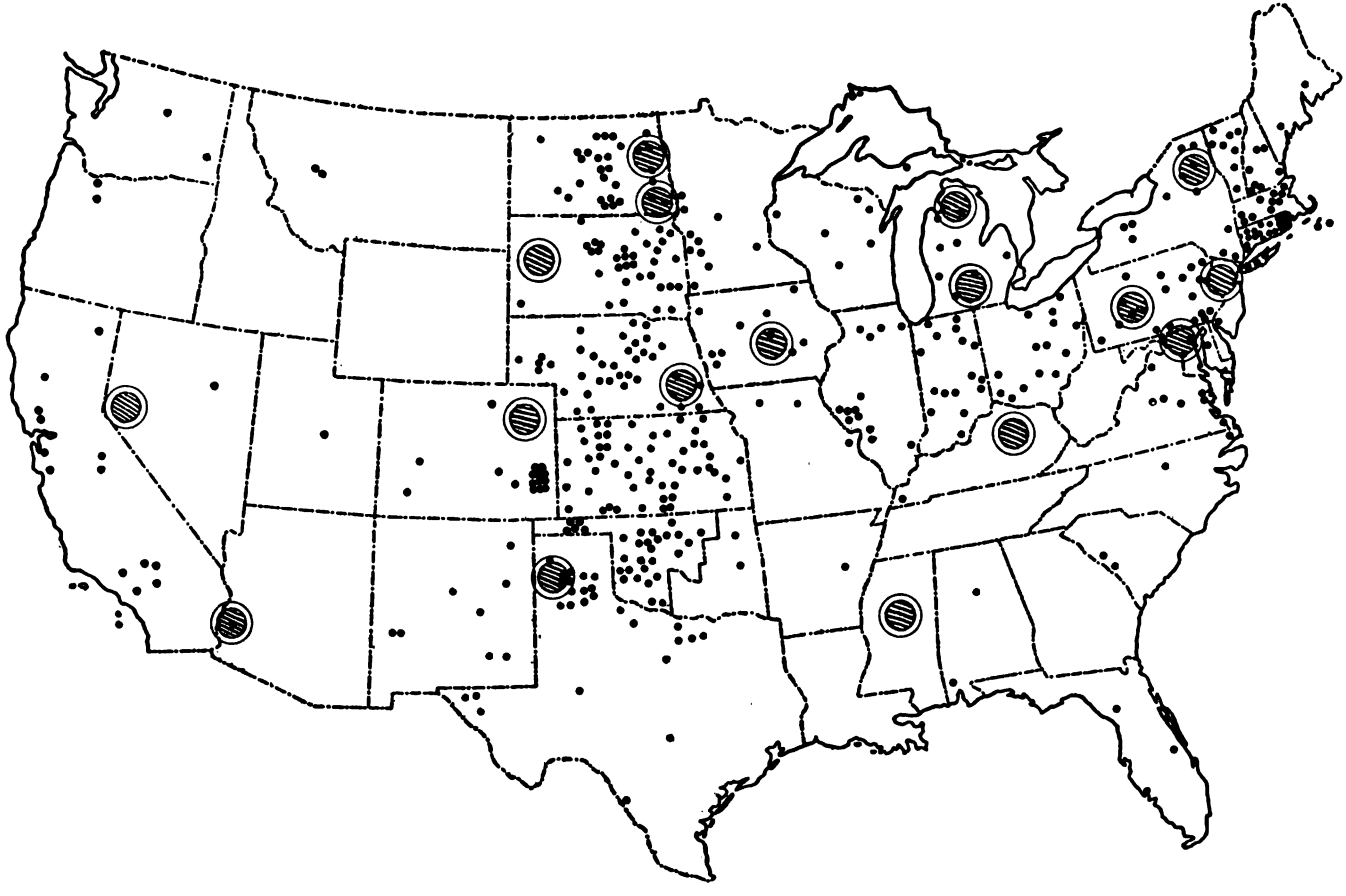

FIG. 2.—FOREST PLANTING.

Points where cooperative nursery and planting experiments are conducted on Bureau of Plant Industry farms and at state institutions.

● Location of planting plans, to July 1, 1908.

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to their highest productive capacity. There are also tracts on many farms now lying idle or being cultivated at a small return, which are best suited for tree growth. These will aggregate a large area.

The total acreage of the eastern region requiring planting, 34,538,079 acres, is divided as follows: Northern forest, 17,853,279 acres; hard-wood forest, 11,532,600 acres; and southern forest, 5,152,200 acres.

The area of land upon which planting is necessary or may be practiced to advantage in the States included within the northern forest was computed from the actual area of cut-over lands, secured from the reports covering a certain percentage of each State, with the exception of Massachusetts, Rhode Island, and Connecticut. For the last State the state forester, Mr. Hawes's, estimate of 500,000 acres was used, and for the other two the area of waste land estimated by state officials.

The area of land requiring planting in the States included within the hard-wood forest was computed from the actual area of cut-over lands, secured from reports covering a certain percentage of each State, with the exception of Maryland, where the state forester, Mr. Besley's, estimate of 20,100 acres was used.

The figure given for the southern region does not include 12,000,000 acres not restocking at present in the Southern States, but on which it is considered adequate fire protection will insure natural reproduction.

The earliest plantations of the East were started by New England farmers, usually without any well-defined purpose other than an impression that the rapid removal of certain species must be met by planting. In recent years the purpose of planting has been more specific, including the production of special materials and the use of waste lands. The estimated acreage of plantations in the States included within the forest regions of the East is 93,111 acres.[a] This is divided among the three regions as follows: Northern forest, 43,346 acres; central hard-wood forest, 41,565 acres; and southern forest, 8,200 acres.

The federal and state governments have played a large part in the recent development of interest in planting, and the extent to which it will be practiced in the immediate future depends to a considerable extent upon the assistance and encouragement from these sources. In the past this help has been chiefly by advice and, to a limited degree, through distribution by several States of stock for planting. In the future it will be necessary for state governments to pay more attention to improving the system of taxation of forest lands and providing for adequate fire protection annually.

The Forest Service has, during the past eight years, prepared 181 plans for the planting of 42,687 acres of private lands in the East. (See fig. 2.) Many recent plans are for large areas, entailing planting annually for a series of years, and the acreage planted up to 1908 is a beginning only. Subsequent planting will increase this acreage much more rapidly. During the fiscal year ending June 30, 1908, 2,437 letters asking advice on planting were received from the eastern region and answered, and circulars dealing with the growing

[a] These estimates are based on planting actually reported for a certain percentage of the area.

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of the more important species were widely distributed. A total area of 3,304 acres planted thus far was reported July 1, 1908, as the result of advice given by the Service through planting plans and correspondence. In addition to this, experiments in nursery practice and planting are being conducted in cooperation with state institutions and forest commissions.

Eleven States have established nurseries under the supervision of state foresters, in which trees are grown for planting in state forests or for distribution among private landowners.

Forest planting will progress as the need of it becomes more generally felt and its practicability is demonstrated. Since planting requires a considerable initial investment and the cost is relatively higher than that required in inaugurating any other form of forest work, the most important factor governing its practicability is fire protection. Other controlling factors in its success are relatively cheap land, a good market for the class of products to be raised, lowest possible initial cost, and a low rate of taxation.

NORTHERN FOREST.

The northern forest offers the largest field for actual planting by States for commercial purposes and as an object lesson to private landowners. The principal state planting problems of magnitude are to be found in Michigan, Wisconsin, Minnesota, and New York. Except for planting on a limited scale for shelter and the restocking of farm wood lots in the various agricultural districts and the reforesting of abandoned farm lands in New England, planting on private lands will be done chiefly by large corporations. The chief opportunities for such planting are in the northern spruce region by lumber companies and in Pennsylvania by coal companies and railroads.

In the New England States, aside from extensive pitch-pine plantations on the sandy areas of the Cape territory of Massachusetts and the islands of Marthas Vineyard and Nantucket, as nearly as can be estimated on an acreage basis from the data at hand, over 90 per cent of the past planting has been done with white pine. Other conifers which have been noted as doing exceedingly well in particular cases are Norway spruce and European larch.

Examples of mature plantations of hard woods are comparatively rare. In experimental work in Connecticut the state forester finds that chestnut, red oak, locust, and sugar maple promise the best success as far as the experiments have been carried, but the plots have only been established a few years.

Planting has been chiefly for the following purposes:

1. Utilization of waste sandy areas unfit for cultivation. Over 10,000 acres of pitch pine were planted for this purpose in eastern Massachusetts; 150 acres in Narragansett Bay region.

2. Fixation of shifting sand. Three hundred and thirty-three acres have been planted to beach grass, bayberry, and pine at Provincetown by the Massachusetts harbor commission.

3. Utilization of cheap abandoned farm and pasture lands by wealthy owners as an investment and for improvement of estates.

4. By water companies to keep the supply clean and to produce wood of various sorts. The Metropolitan water board, Boston, has planted 1,100 acres on its watersheds.

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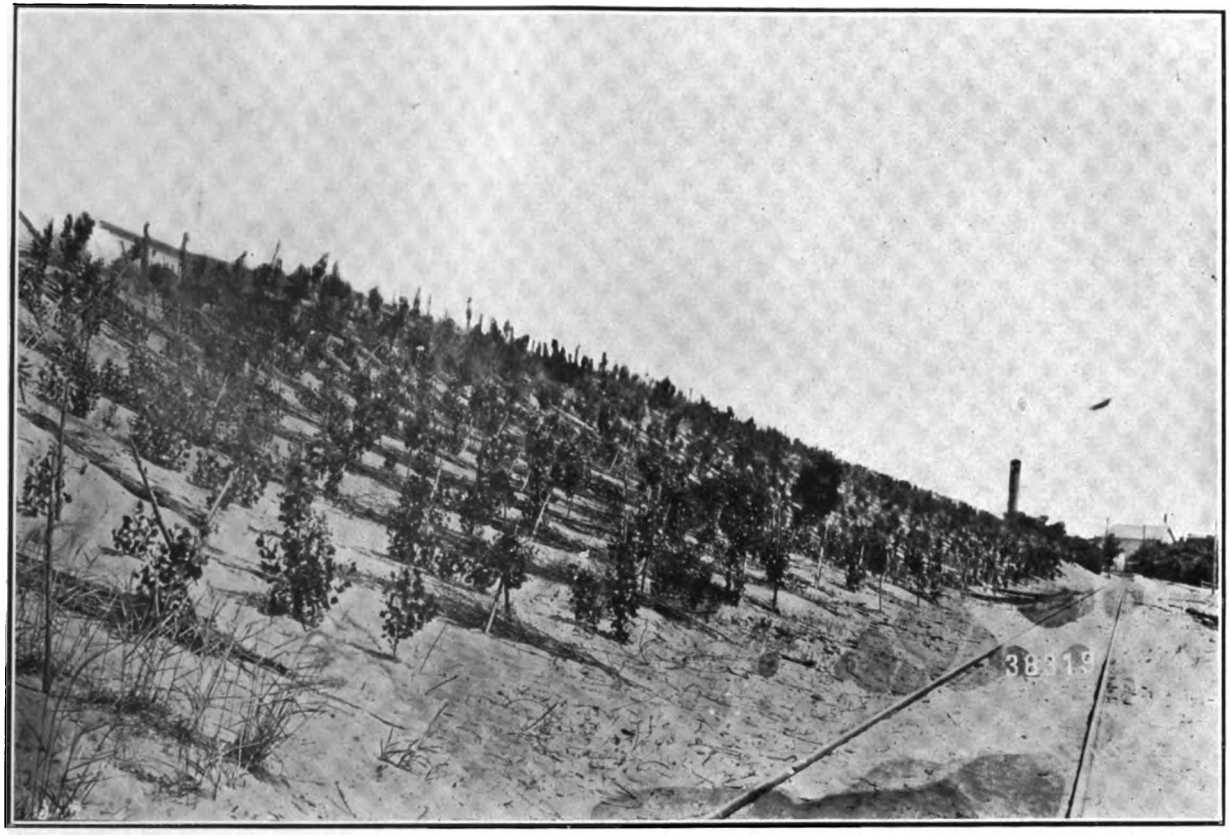

SAND DUNE RECLAMATION, MANISTEE COUNTY, MICH.

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5. By box-board companies, stave and heading manufacturers, to provide material for future manufacture.

6. By the State for experimental and educational purposes (Connecticut).

The Boston and Maine Railroad has set out 15 acres of white pine, principally for educational purposes. This company is also experimenting with hard woods in various parts of New England.

Past forest planting in the region has been of great economic importance, particularly in Massachusetts, Connecticut, and Rhode Island, in proving the practicability of forest planting for the utilization of sandy waste lands, abandoned farm lands, and for the production of box-board material.

Commercial companies have been aroused through a growing scarcity of timber. Those companies utilizing second-growth white pine began some ten years ago to increase their holdings of pine-wood lots varying in age from forty to sixty years; next they purchased thirty to forty year old stands; then lands having ten to thirty year old stands of pine; and within two years they have begun planting.

The practice of planting is decidedly on the increase, especially in Massachusetts, Connecticut, New Hampshire, and Vermont, but in Maine to a lesser degree. It is not on the increase in Rhode Island, but will undoubtedly be taken up when efficient fire protection and proper taxation are secured.

The progress by periods in Massachusetts has been estimated as follows: 1820–1880, 10,000 acres white pine planted;[a] 1880–1894, little planting done; 1894–1902, about 5,000 acres planted.[b]

During 1908 over 2,500 acres have been planted in New England.

Connecticut, Massachusetts, and Vermont distributed about 1,500,000 seedlings last year, which have not supplied the demand. One private firm disposed of 1,000,000 seedlings. Beginning in the spring of 1907 the state nursery of Vermont has since distributed or helped order perhaps 100,000 seedlings per year. This quantity, although relatively small, has been of quite disproportionately high educational value, since on account of it some fifty to one hundred other persons scattered over the State have made small trial plantations and have succeeded so well that they will continue the work. Almost every farmer in Vermont may wisely do a certain amount of planting under the direction of the state officials. The most hopeful places to begin the practice of forestry are the old, weedy back pastures which are now lying practically waste. Next to this is the filling in of blank spaces in natural stands. The farmer in Vermont will undoubtedly improve and plant his wood lot before the lumberman takes up planting to any great extent. It will, in fact, become a regular part of farm management.

White pine is considered the species surest of success. Red pine is of great value, especially for the drier soils, and the state experiment station is using Scotch pine on dry sands. Norway spruce is of especial promise for moist, strong land of the high mountain valleys—that is, all the natural spruce land. Small plantations of black locust are being tried for the purpose of producing posts and stakes.

In the immediate future State Forester Hawes believes that the

[a] Bulletin 45, The Planting of White Pine in New England, Bureau of Forestry.
[b] Estimate of H. B. Kempton, Woodland and Roadside, March 1, 1903.

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greatest amount of planting in Connecticut will be done by wealthy owners as a side investment.

In New Hampshire, Forester Ayres thinks that there will not be much planting purely for timber supply in the next few years, but that a great deal of planting will be done on a small scale as a part of farm management. There are several instances of plantations just started by manufacturing companies. One of these, a cooperage company, has planted 225 acres of white pine on a fifty to sixty year rotation, for stave and heading stock. Water companies in general are reported to be taking up a forest policy. In New Hampshire the species proving most suitable for planting are white pine and Norway or red pine for sandy soils and Norway spruce for loamy soils.

In Massachusetts wealthy land owners are doing considerable planting. State Forester Rane has distributed white ash (one-year seedlings) on a large scale throughout the State during 1907 and 1908. Experiments with this species so far in Connecticut have proven unsatisfactory.

In Connecticut the conifers best adapted for planting on the sand plains are Scotch pine, white pine, Norway pine, and pitch pine, and the hard woods which promise best are chestnut, red oak, locust, and sugar maple.

It is estimated that there could be harvested to-day from plantations in New England about: White pine, 5,000,000 feet b. m.; chestnut, 25,000 feet b. m.; locust, 4,000 feet b. m.; and other hard woods, 5,000 feet b. m.

The great bulk of the plantations of white pine now in existence have been established within the last few years and will not be ready to harvest before 1930 at least. Something like 200,000,000 feet b. m. could be harvested between 1930 and 1950 from plantations already established if they are successfully maintained. Granting that one acre will yield 25,000 board feet at the end of forty years, all the stock planted in 1908, if successfully raised and harvested, in 1948 would yield 62,500,000 feet b. m.

The increasing field for forest planting in the New England States is indicated strikingly by the rapid decrease in recent years of the area of improved land in farms. This decreased from 11 per cent in Maine to 20 per cent in New Hampshire between the years 1890 and 1900, according to census figures. There are 2,500,000 acres in New England needing planting.

In New York State, aside from the restocking of forest lands in the mountain regions, forest planting is advisable for improving and renewing farmers' wood lots and making productive the waste areas on farms. The chief purpose of planting will be timber supply, and the species which are best adapted and which promise highest returns are white pine, red pine, Norway spruce, chestnut, red oak, basswood, tulip poplar, white ash, and in moist places Carolina poplar. The practice of planting is increasing rapidly. The work of the State in the Adirondacks is a remarkably fine example of good nursery practice and planting.

Pennsylvania divides readily into three sections where conditions of surface, soil, and climate are enough differentiated to modify the practice of tree planting in each.

The southeastern plains extend from tide water along the Delaware westward and northeastward along the Blue Mountains, which form

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FIFTY-YEAR-OLD WHITE PINE PLANTATION.

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the northern boundary of Cumberland, Lebanon, Berks, Lehigh, and Northampton counties. This was an early settled farming region, nearly every farm having its wood lot. Very few of these wood lots are in good condition, and in some cases this has caused the owners to become interested in forestry, and more or less tree planting has followed. The average prices of cordwood and fence posts and farm repair material generally are higher in this section than in any other portion of the State. This feature, coupled with the value of the land for agriculture, makes this region a splendid field for farm planting for quick-growing species that will produce in a comparatively short time fence posts and other timbers needed on the farm. More planting has thus far been done in this section of the State than in any other. The early purposes of planting were rather vague. Two classes of species were used—white pine, which was extensively planted and leads the class of slow growers, and the black locust, the most frequently planted of the rapid-growing species. No great degree of success has been attained, and the chief value of the early planting has been the creation of a general interest in tree planting among the people and the determining of the value of various species for planting. The great area of the near-by central mountain region, which is more valuable for tree growing than any other crop, makes it undesirable to devote these plains to other than rapid-growing species for the production of small-sized material.

Species which seem to give the best promise for planting are red oak, European larch, tulip poplar, and, where the wood can be given preservative treatment, cottonwood, silver maple, white willow, loblolly pine, and pitch pine. Catalpa has proven successful enough to justify its limited use on rich soils, and, with proper methods of growth, should prove a valuable post tree.

The central mountains comprise a broad belt extending from the northeastern part of the State southwestward to Maryland and West Virginia. This entire section was covered originally with splendid forests of pine, hemlock, and hard woods. The presence of unexcelled markets on the lake toward the north and along tide water toward the south will make the practice of forestry in this section as profitable as in any portion of the East. Excepting over the barren portions of watersheds that are supplying water for domestic use, there is no section of these central mountains in which extensive tree planting will be necessary, especially in view of the present inability of the owners, whether State or individuals, to protect their lands from fire. While the danger from annual or periodical fires is as great as now, it will not be a profitable thing to attempt to increase the value of these forests by general planting. As soon as the fire danger is diminished, natural reproduction will undoubtedly restore a forest cover that would compare well in density and composition with the original forest and should be supplemented by planting. In the central mountains the planting should be of white pine and spruce, and hardwoods such as red and scarlet oaks, tulip poplar, white ash, and basswood.

The western hills comprise a section in the northwestern part of the State extending from the Allegheny River westward to the Ohio line and Lake Erie. This section ranks next to the southeastern plains in agricultural value, yet contains a much larger amount of land adapted to tree planting in proportion to the total area.

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The practice of planting would undoubtedly add materially to the general value of both farm and forest areas. Since there are considerable areas of essentially nonagricultural land separating the agricultural sections, slower growing species for the production of large timbers could be used profitably, while, as on the southeastern plains, quick-growing species may be planted to advantage on many of the farms. Thus far very little planting has been done in this section. In the western hills the soil is admirably adapted to white pine, European larch, and such hardwoods as red, yellow, and scarlet oaks, white ash, basswood, honey locust, and such rapid-growing species as cottonwood, soft maple, and white willow.

In the Lake States the practice of planting is increasing rapidly. They are divided into a southern hard wood forest and northern coniferous forest. The principal species planted have been white pine, Scotch pine, Norway pine, European larch, and, to some extent, the more rapid growing hardwoods such as locust, catalpa, black walnut, cottonwood, ash, and elm. In these States, where there is the greatest field for reforestation of cut-over lands, the united work of private individuals and of the state governments in reforesting nearly 13,000,000 acres will mean the rebuilding within seventy-five years of the lumber industry, which at its period of greatest activity produced nearly 40 per cent of the total cut in the United States.

CENTRAL HARD-WOOD FOREST.

In the States included within the hard-wood forest, planting will be done by farmers, to a limited extent, for protection from winds and to check erosion, but chiefly for the utilization of waste lands on farms; by mining companies, railroads, and manufacturers on nonagricultural lands for the production of pulp wood, box boards, mine props, ties, piles, posts, etc. The work of the various state governments in this region will be largely confined to assistance and encouragement of planting by various means, such as the distribution of publications containing advice and information, distribution of stock from state nurseries, and the conducting of forest work on state reserves, which will serve as an object lesson to private landowners. Such reserves on which planting is already being done are owned by Connecticut, Indiana, Michigan, New Jersey, New York, and Pennsylvania.

In New Jersey the principal species which have been planted in the past are white pine, Scotch pine, white ash, and white elm for purposes of timber production. The practice of planting is increasing greatly. It is, however, considered by the forester of the state forest park reservation commission to be relatively unimportant, and necessary only on abandoned fields. The species which give the best promise are the most rapid growing of the conifers.

In the central valley States the species chiefly planted have been as follows: West Virginia and southwestern Pennsylvania, walnut, locust, sugar maple, red oak, chestnut, and catalpa for posts, mine props, and timber; Ohio, black locust and catalpa for posts; Indiana, black locust, catalpa, and walnut; Kentucky, black locust, catalpa, tulip poplar, maple, and walnut, principally for mining timbers and posts; Tennessee, locust, maple, and cedar; Missouri, catalpa, locust, walnut osage orange, cottonwood; and Arkansas, locust and walnut.

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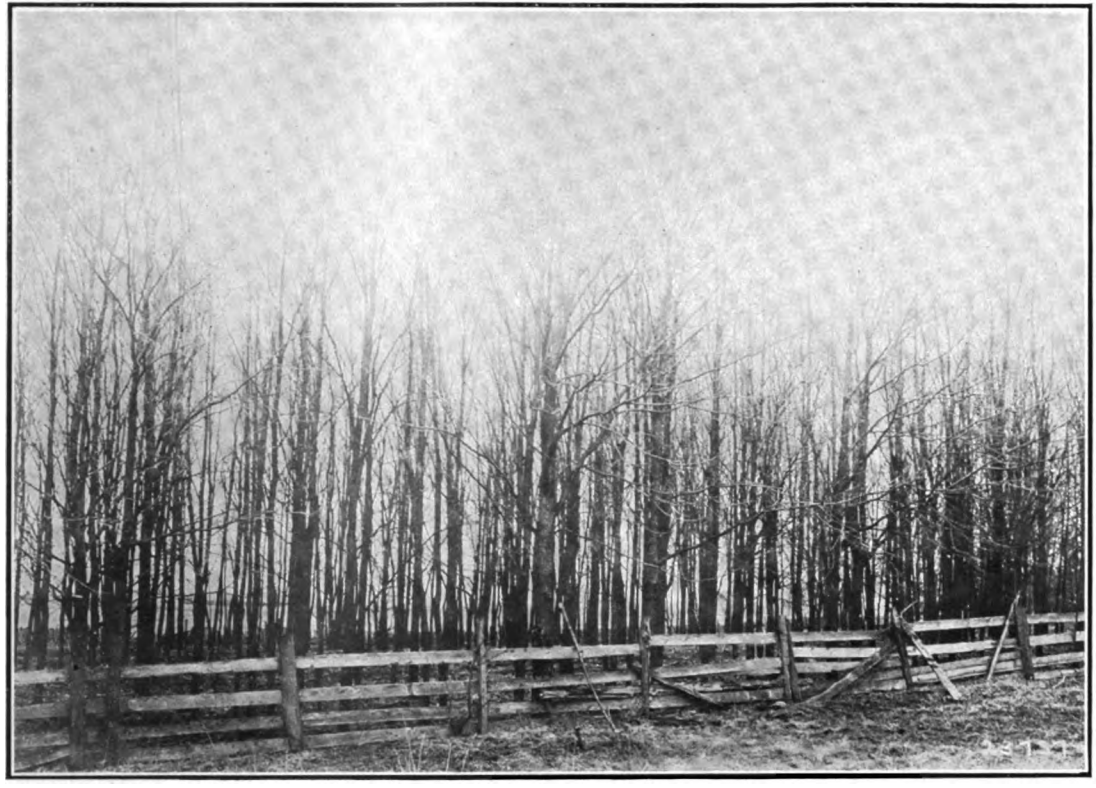

20-YEAR-OLD BLACK WALNUT PLANTATION FROM SEED, TIPPECANOE COUNTY, IND.

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SOUTHERN FOREST.

In the southern forest region the artificial restocking of denuded areas will be almost wholly the concern of lumber companies and other large landholding corporations and will consist chiefly of seeding with native pines to supplement the protection and management of forest lands, which for the most part are reproducing naturally.

Of the total area of cut-over forest land which is not restocking naturally, it is estimated that probably 70 per cent will reproduce well to pine if protected from fire for a long enough period. Thirty per cent, or 5,152,200 acres, is therefore given as the area requiring artificial restocking. While most of this area lies within the southern pine forest, there are limited opportunities for planting in the Appalachian Mountain region and in the northern portions of Georgia, Alabama, and Mississippi. Planting thus far has been almost altogether of rapid-growing hard woods, such as catalpa, and was for the most part ill advised. It serves as no indication at all of the lines along which planting will progress in the future. The hardy catalpa is practically unsuited for planting in any portion of this region. For quick production of material in small sizes, black locust is especially well adapted for the mountain and Piedmont sections of Georgia. The white oak is well adapted for planting in Georgia for the production of posts, ties, etc. For post production it will, however, probably prove most profitable to grow loblolly pine and treat it with preservatives. Carolina poplar grows rapidly in the South and makes good chemical pulp. The practicability of planting this, however, is somewhat in doubt, since it has been found that pine can be used for pulp.

In general, it may be said throughout this region that planting is unnecessary, since reproduction of the longleaf and loblolly pines is abundant wherever cut-over forest lands or abandoned farm lands are protected from fire.

CENTRAL TREELESS REGION.

The area included within this region comprises the States of Illinois, Iowa, North Dakota, South Dakota, Nebraska, and Kansas, the prairie district of Minnesota, and the portions of Oklahoma and Texas lying west of the hard-wood belt.

Tree planting in this region was begun on a considerable scale some thirty or forty years ago, to provide shelter from the heavy winds. In extent of past planting, it is the most important region of the United States.

An effort was made to stimulate interest in planting on the western prairies and plains in the years 1873–74 by the passage of timber-culture acts. Many tree claims were started in the treeless region under these acts, but owing to the crude provisions of the law and the lack of knowledge regarding planting on the part of the homesteaders, the securing of much land by fraudulent means resulted and the planting accomplished has in the aggregate been of relatively small value. The law was repealed in 1891.

Planting has followed the progress of agriculture, and has been most extensive in the region of best agricultural development. Ne-

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braska and Kansas lead in the acreage of plantations. Assessors' figures compiled in 1904 indicate that Nebraska had 286,000 acres of planted timber at that time, and it was claimed that Kansas had 142,984 acres of plantations in 1900. The area of private forest planting of which there is record in all the States included within this region is 752,443 acres. The total estimated area of past planting is 830,954. That which should be devoted to this purpose is estimated to be in the aggregate nearly 15,000,000 acres.

In early planting for protection, the tendency was to make use of rapid-growing species which could be obtained cheaply, without regard to their final commercial value in plantations. Owing to poor selection of species, indiscriminate planting on sites not suitable for the species used, and ignorance of proper methods, much of this early planting has given very poor results. As a result, however, of the very large extent to which planting has been done under widely diverse conditions, the problems of this region are fairly well solved and the lines of future development clearly indicated. Sufficient success has been attained to demonstrate that, with a right choice of species and methods, forest planting for commercial purposes is practicable.

As in the past, planting in this region will be almost entirely a private enterprise, carried on in connection with farming. While protection is and will be in general the primary object, planting will be done from the commercial standpoint, since by using only profitable species it will easily be possible to secure the advantages of shelter and ornament, and at the same time derive a revenue from all the plantations.

Until quite recently planting was for a number of years on the decline or at a standstill in the older farming regions of Illinois, Iowa, Nebraska, and Kansas. The cutting of mature plantations offset in acreage what new planting was being done. As might be expected, the planting of shelter belts is greatly on the increase in the newer farming districts of the Dakotas and Oklahoma, and, owing to the increasing evidences of the value of plantations, interest in planting is again being revived throughout the region. The following figures, giving the comparative distribution of stock for the past three years, by forty-five of the principal commercial nurseries which handle forest-tree seedlings, show the increase of interest, since the greater portion of this stock was sold for planting in the prairie region: 1906, 24,530,929; 1907, 38,540.202; and 1908, 40,791,193. Of these trees, 70 per cent were hard woods and 30 per cent conifers.

The advantages and the necessity in most cases of having a certain proportion of the land in agricultural districts under forest cover have been clearly demonstrated, and it is considered that 5 per cent of the prairie region should be forested for the best interests of agriculture. Farther west on the plains, 3 per cent of the land may very well be devoted to tree growing. The ninety-ninth meridian is arbitrarily used as the dividing line, 5 per cent being used for States or parts of States east of this meridian and 3 per cent west. Figures on the area of land that should be planted are obtained by subtracting the area of land already planted from 5 per cent or 3 per cent of the total area, according to the location of the State.

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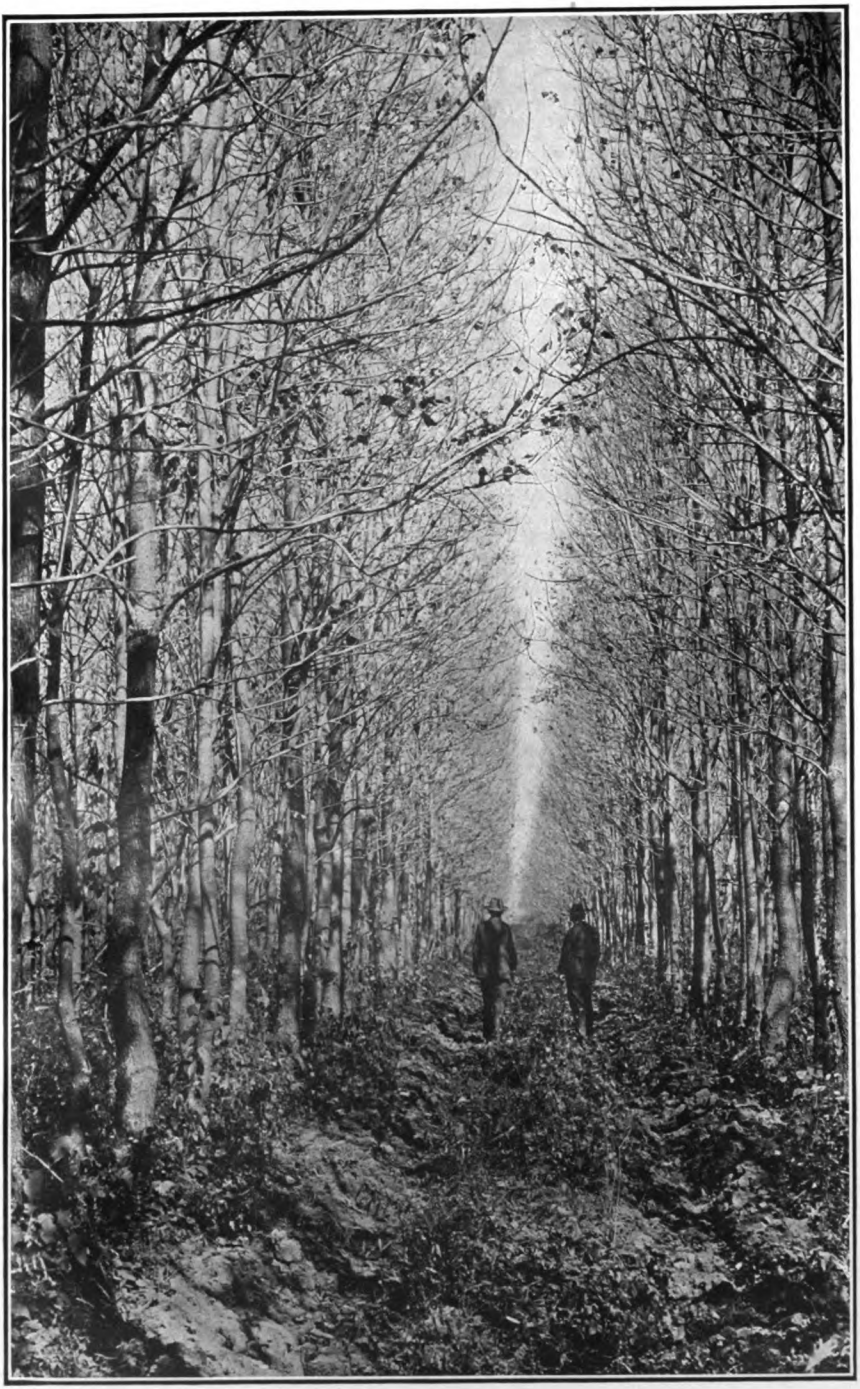

PLANTATION OF HARDY CATALPA, KANSAS.

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27-YEAR-OLD EUROPEAN LARCH PLANTATION, ILLINOIS.

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Figuring on this basis and that of the acreage already forested, there remains 14,160,246 acres on which planting is very desirable and may be done to good advantage. In addition to this there are about 653,352 acres of grass land in the sand-hill district of western Kansas and Nebraska, now under the control of the Federal Government, as much as possible of which it is intended to forest for the production of commercial timber and as an object lesson to the people of the region.

Owing to the fact that the opportunities for tree planting and the practicability of it became earliest apparent in the treeless States, the first efforts of the Forest Service for the encouragement of planting were directed toward this region. Since 1899, 223 planting plans have been made for private landowners, covering a total acreage of 5,488. (See fig. 2.) During the fiscal year ending June 30, 1908, 1,129 letters asking for advice on planting were received from this region and answered, and there has been a wide distribution of circulars dealing with the results of careful studies which the Service has made of the districts most important from the tree-planting standpoint. Up to July 1, 1908, a total area of 1,072 acres has been reported planted as the result of advice given by the Service by planting plans and correspondence. Experiments to determine the value of various species and methods are being conducted in cooperation with the States of North Dakota, Nebraska, and Iowa.

All of the States in this region have taken more or less interest in forest planting. Minnesota expends $20,000 annually in bounties for tree planting in the prairie sections of the State. Kansas maintains a state nursery, from which trees are distributed to private landowners, and experimental planting is being conducted by state institutions in six of the States. Owing to the nature of the planting problems in this region, the future action by States will be wholly along the line of demonstrating to private landowners the practicability of planting and the best methods.

ILLINOIS.

Although the southern portion of this State is properly included within the central hard-wood region, it is considered a prairie State. Seventy per cent of the total area was reported upon by county clerks; 10,898 acres of planted timber were reported, making the estimated total of past planting 15,568 acres. The area upon which planting is desirable is 1,456,526 acres. According to reports received, the practice of planting is waning. The species chiefly used in the past were black walnut and hardy catalpa, and the chief purposes were for shelter belts, for production of posts, and for fuel.

IOWA.

Prof. C. A. Scott estimates the area of past planting to be 125,000 acres. While this figure is considerably more than that reported by county clerks, it seems reasonable, and was used. The area upon which planting is desirable is 1,929,752 acres. Planting is reported to be decidedly on the decline. The species reported to have been planted chiefly are, in the order of their predominance, silver maple,

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black walnut, cottonwood, boxelder, willow, ash, elm, and catalpa. Shelter ranks first among the purposes of planting, with fuel, posts, and timber supply next in order.

MINNESOTA.

The western and southern prairie portions are included in this region. The total amount of past planting, as estimated by General Andrews, state forest fire warden, is 115,000 acres. The area of land which should be planted is 1,178,728 acres. The practice of planting is reported to be slightly on the increase. The species which are most commonly planted are boxelder, cottonwood, maple, willow, ash, and elm, for purposes of timber production, shelter, and fuel.

NORTH DAKOTA.

An area of 44,746 acres of planted timber was reported from 86 per cent of the area of the State. The total area of past planting is estimated at 52,030 acres. The area upon which planting should be done is 1,578,000 acres. Three per cent of the area of irrigation projects in this State (2,280 acres) is also included in the total to be planted. Planting over the entire State is reported to be increasing rapidly. The species chiefly used are boxelder, cottonwood, green ash, and willow, and the chief purposes of planting are for shelter and post production.

SOUTH DAKOTA.

The actual area of planted timber, secured from reports covering 71 per cent of the total area of the State, is 86,638 acres. The total area of past planting is estimated at 122,025 acres, of which 110,462 acres are east of the ninety-ninth meridian. The total area of land upon which planting is desirable is 1,788,238 acres. This includes 3,000 acres of land on irrigation projects and 150,000 acres of land requiring planting in the Black Hills National Forest. Planting is reported to be on the increase in this State. Boxelder, ash, cottonwood, elm, and soft maple are the species chiefly planted, for purposes of shelter, fuel, and posts.

NEBRASKA.

An actual area of 167,137 acres of planted timber was secured from reports covering 87 per cent of the State. The estimated total area of past planting is 191,996 acres, of which 133,541 acres lie east and 58,455 acres lie west of the ninety-ninth meridian. The area in the State which should be planted is 2,093,803 acres. The total includes 900 acres of land on irrigation projects and 556,072 acres within the Nebraska National Forest. The practice of private planting is reported to be slightly declining. The species chiefly used in the past have been cottonwood, boxelder, ash, elm, and maple, for purposes of shelter, fuel, and posts.

KANSAS.

Reports were received covering practically the entire State. The total area of planted timber is 175,023 acres, of which 154,131 acres

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21-YEAR-OLD PLANTATION OF HARDY CATALPA, IOWA.

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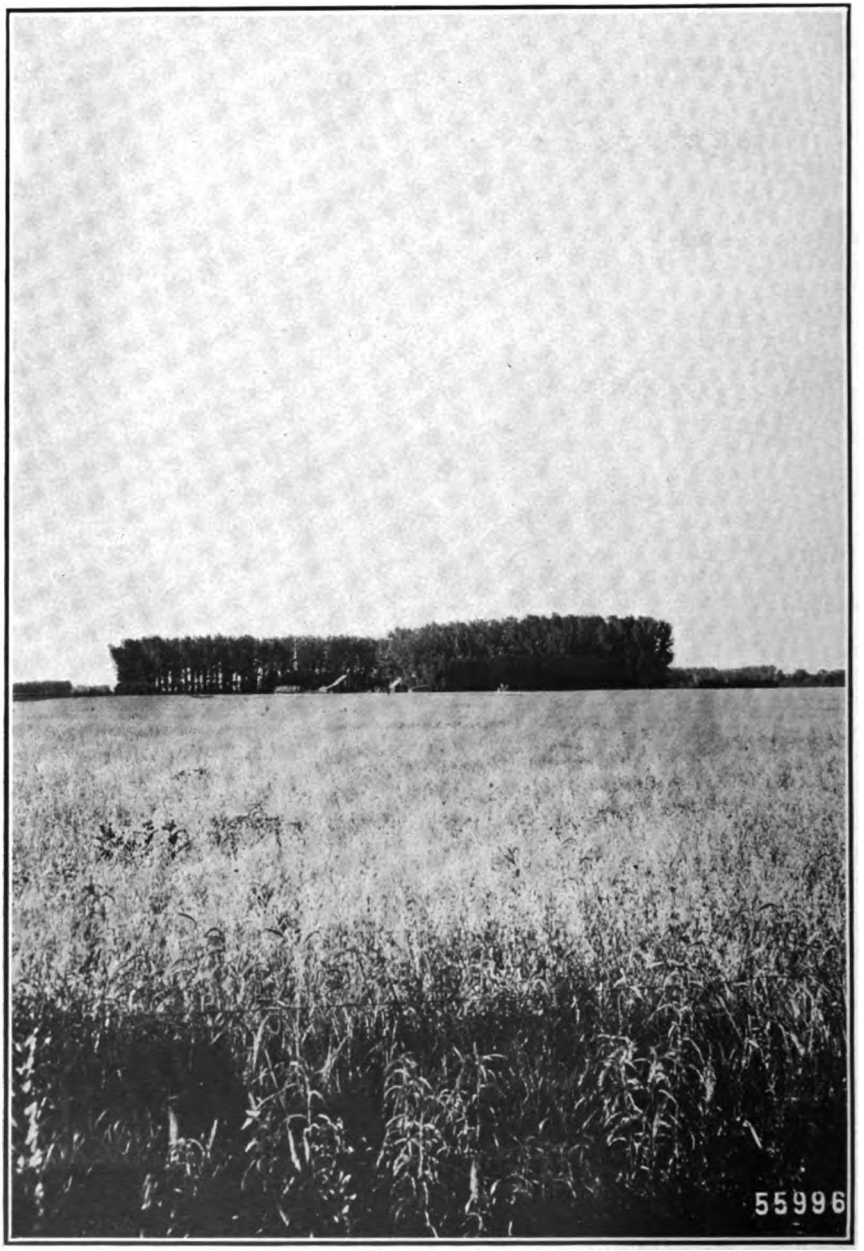

PROTECTIVE AND COMMERCIAL PLANTING YANKTON COUNTY, S. DAK.

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lie east and 20,892 acres west of the ninety-ninth meridian. The area which should be planted is 1,963,853 acres. The total includes 240 acres of land on irrigation projects and 302,387 acres within the Kansas National Forest. The practice of private planting seems to be about at a standstill. The species chiefly planted have been cottonwood, black locust, hardy catalpa, black walnut, and ash, for purposes of shelter and production of posts and fuel.

OKLAHOMA.

Only that portion of the State which lies west of the ninety-ninth meridian has been included in the central treeless region. The area of planted timber in this portion of the State is 21,143 acres, secured from reports covering practically the entire area of the region. The area which should be planted is 317,044 acres, which includes 5,000 acres of land requiring planting within the Wichita National Forest. The practice of planting in this region is increasing rapidly. Locust, catalpa, maple, and cottonwood are the species chiefly planted, for purposes of post production, shelter, and fuel.

TEXAS.

Only that portion of the State which lies west of the ninety-ninth meridian is included in this region. Of past planting 6,848 acres were reported from 52 per cent of the total area. The estimated area of past planting for this portion of the State is 13,169 acres. The area which should be planted is 2,507,651 acres. This includes 1,800 acres of land on irrigation projects. The practice of planting is reported to be increasing very rapidly. Black locust, cottonwood, and catalpa are the species chiefly planted for purposes of shelter and the production of posts and fuel.

WESTERN REGION.

This region includes the Rocky Mountain and the Pacific coast States. Nearly all of the forest land in the western States, with the exception of Washington, Oregon, and California, is within national forests, thus making forest planting on these lands chiefly a federal problem. Aside from this, the principal opportunities for planting occur in the valleys of southern California and on irrigated lands throughout the region. The total area of land which it is essential should be forested is over 7,000,000 acres.

PRIVATE FOREST PLANTING.

On irrigated lands the primary purpose of planting by private owners is identical with that of the central treeless region. Most of the projects are so located as to be subject to strong winds, and protection is essential. Forest planting by individuals in California includes both protection of orchards and the production of commercial timber.

The total area of planted timber in this region is estimated to be 38,862 acres, of which 37,100 acres have been done by private landowners. This estimate is based on the area of past planting actually

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secured from county reports. The most interesting and economically valuable planting in the region is (1) an aggregate of 20,000 acres of commercial plantations of eucalypts in California and (2) the annual planting work of a paper company in Oregon for the production of pulp wood, a total of 1,100 acres up to 1908. The former presents one of the most remarkable cases of profitable returns from a quick-growing species, and shows the value of further experiments with exotic species in the United States. The latter is a notable example of the feasibility of planting for a special purpose, even in a well-timbered region.

If the proper species of trees are used, the difficulty of securing good shelter belts and woodlots will be no greater on western irrigated lands than in the central treeless region. Eastern species of trees have proved most useful in the small amount of planting done thus far. Ash, cottonwood, locust, and elm, introduced species such as Norway spruce and Scotch pine, and many other trees have been planted. The choice of species depends chiefly upon latitude and altitude since moisture can be controlled by irrigation. There is often such a wide difference in conditions within a section of a State that different trees must be chosen. For example, in the upper Snake River Valley, in eastern Idaho, only hardy conifers and broad-leaf trees are suitable, while in the western part of the State, in the lower Snake River Valley, nearly all eastern hard woods may be grown.

There are now about 11,000,000 acres of land under private irrigation, and there will be 1,910,000 acres under government irrigation by 1911. There yet remains 60,000,000 acres judged to be susceptible eventually of irrigation. At least 3 per cent of such land may be devoted to tree growing to good advantage, and if this is done planting will have shelter as its chief purpose, but incidentally the production of useful farm materials.

The development of planting in California has been more rapid than in any other State in the region. High returns from plantations have already been secured, and the southern part of the State is likely to be a great producer of eucalyptus (hard wood) timber for many uses, especially furniture and wagon stock.

It is estimated that there are at least 1,000,000 acres of land in the valleys of southern California upon which continued irrigation for the production of fruit is not feasible, but which can be irrigated temporarily and are well suited for the growing of eucalypts. The principal work of the State in this connection thus far has been in the nature of advice and giving out publications dealing with planting.

The Forest Service has during the past few years made examinations of 15 of the 28 government irrigation projects to determine the species best adapted for planting by settlers, and experiments in tree planting are being conducted on several of the projects. Since 1900, 48 planting plans have been prepared for private landowners in the States included in the western region, covering a total of 15,779 acres. (See fig. 2.) Approximately 809 letters asking advice on planting were received and answered during the year ending June 30, 1908, of which 460 were from California; in addition, a very large amount of correspondence has been answered by the state forester. Partial returns show that 470 acres have been planted up to

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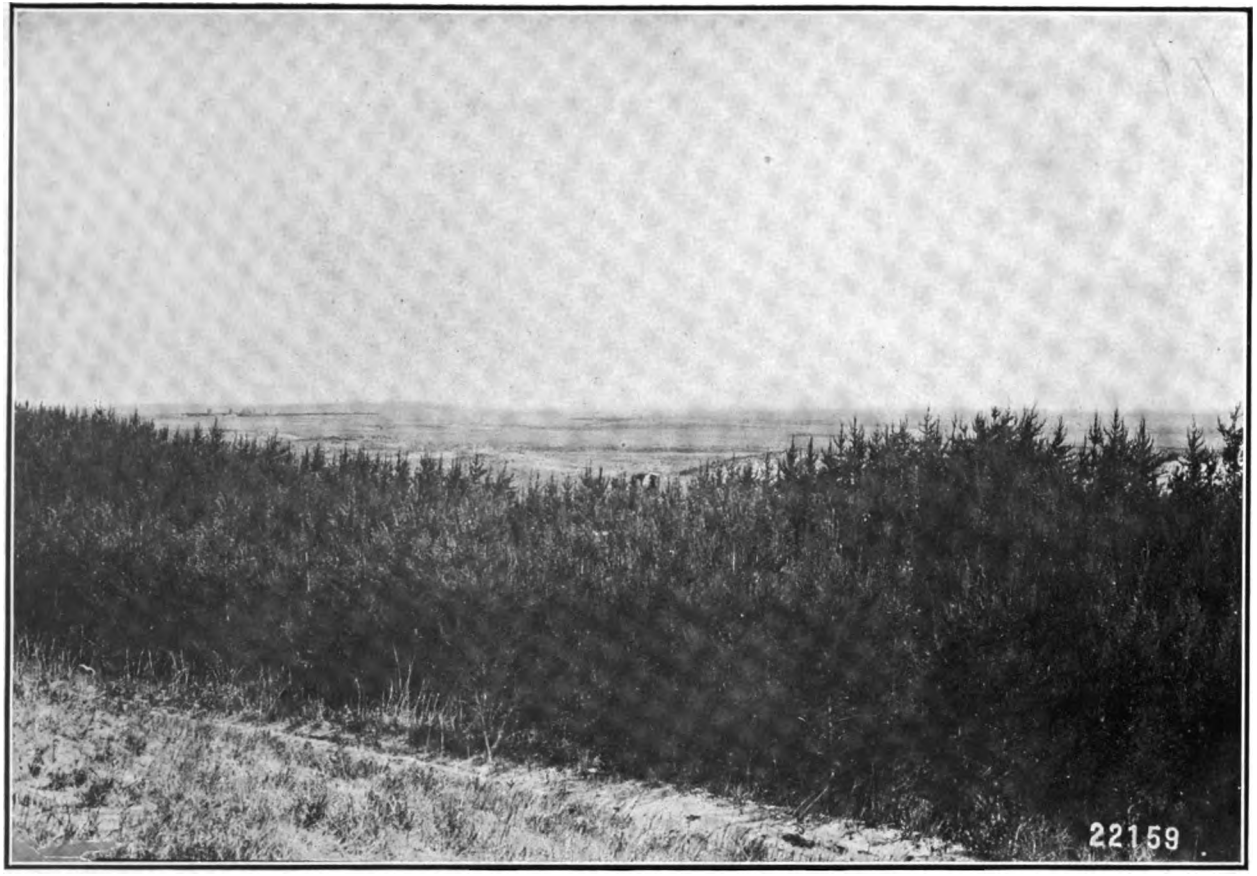

GOVERNMENT EXPERIMENTAL PLANTATION OF JACK PINE, HOLT COUNTY, NEBR.

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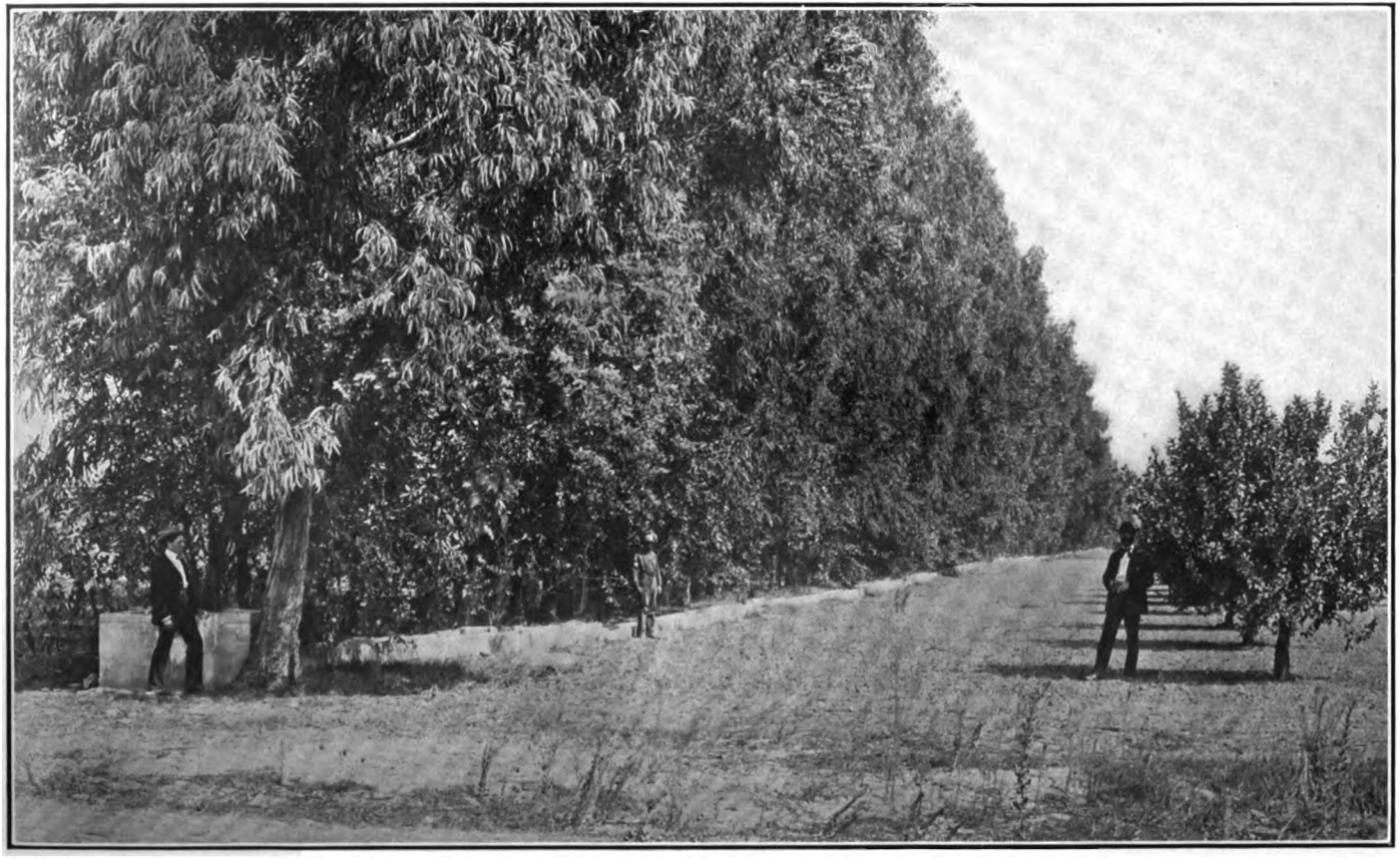

EUCALYPTUS WINDBREAK PROTECTING LEMON ORCHARD, SAN BERNARDINO COUNTY, CAL.

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July 1, 1908, as the result of advice given by the Service through planting plans and correspondence.

The principal forest lands outside of national forests lie in Washington and Oregon west of the Cascades, and in California. Possibly 25 to 30 per cent of cut-over lands in the former section will be devoted eventually to agriculture. Adequate fire protection and proper forest management will provide for a future timber supply on the balance of these lands. Planting will be a small factor only and supplemental to forest management, in order to restock areas that can not reseed naturally because of lack of seed trees.

It is estimated that in addition to the national forest land requiring planting an area of 276,640 acres of cut-over private lands must be artificially reforested, and that tree planting is desirable on 2,586,340 acres on irrigation projects and other treeless farming regions. In preparing these estimates for that portion of the region not included within national forests, the area of cut-over land not restocking naturally in private ownership was found by computing from figures secured from county reports. To these amounts were added 3 per cent of the area of irrigation projects to be completed by the Reclamation Service by 1911, and 3 per cent of the area of farm land in each State, less the area of past planting in that State.

NATIONAL FOREST PLANTING.

Over 5,000,000 acres in national forests will require planting eventually. The following table shows the area to be planted by States:

State.	Area requiring planting in national forests.	State.	Area requiring planting in national forests.
	Acres.		*Acres.*
Arizona	255,000	Oklahoma	5,000
California	1,113,500	Oregon	150,000
Colorado	932,500	South Dakota	150,000
Idaho	228,000	Utah	174,000
Kansas	302,387	Washington	103,500
Minnesota	10,000	Wyoming	637,000
Montana	434,000		
Nebraska	556,072	Total	5,276,959
New Mexico	226,000		

The total area to be forested represents approximately 3 per cent of the total area of all national forests. These figures are based on the reports of supervisors and other officers of the Forest Service; in many cases the acreage has been determined by a careful examination of the forest. The areas given for Kansas and Nebraska consist of treeless sand-hill land; that given for California includes chaparral land, some of which was never natural forest land. With these exceptions the 5,000,000 acres represent natural forest land that has been denuded by lumbering and fires and which must be planted if it is ever to become productive. After considerable experimenting it may also be found possible to afforest a larger area in addition to this, such as brush lands in the arid region.

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There are two principal purposes in future national forest planting—protection of important watersheds and the production of commercial timber. The distinction made in classifying protection areas is the importance of the denuded slopes in protecting the water supply of near-by towns and cities, and streams furnishing water for irrigation projects in the immediate region. Lands to be planted that have a more remote protective influence, and the chief importance of which lies in planting them to make the land productive again for future needs, have been classified under commercial planting areas. Both purposes are often involved, but the areas given above may be divided according to purpose, as follows:

	Acres.
Protective planting:	
City watersheds	280,000
Irrigation watersheds	1,485,500
Planting to produce commercial timber	3,511,459

To meet this need it has been necessary to experiment carefully in order to determine the best methods and species to use. Attention has been paid, first, to city watersheds, and eight nurseries have been established within a period of five years, having a capacity of approximately 5,000,000 trees. Not all of these have trees old enough to plant, but there are now 2,250,000 trees ready for planting, and this figure will increase annually. Two of these nurseries provide trees for planting in the sand hills of Nebraska and Kansas. This planting is to serve as an object lesson to the people and to provide useful material in the future for this region. The others provide trees for watershed planting to improve the condition of water supply in Colorado, Idaho, Utah, California, and New Mexico.

In addition to planting trees, experiments were begun recently to determine the practicability of seed sowing on the sites where a new forest is desired. Less than a ton of seed was used in 1907 in a series of experiments on 27 forests in 8 States. In 1908 over 6 tons of seed were secured to extend this work materially. Success has been obtained by this method in reforesting burned areas of yellow pine in the Black Hills National Forest. It seems likely that reforestation by seeding will be largely successful in northern forests and at high altitudes where moisture is more abundant. Planting will be absolutely necessary on the drier situations having less brush and grass cover, and especially in the southern forests.

All sowing and planting work is planned ahead for a five-year period and preceded by a careful study of the forest.

Only 1,762 acres have been forested since the work began, but this area represents many situations and conditions, and valuable data have been secured bearing on future work. In addition to this great task of reforesting 5,000,000 acres of denuded land, planting and sowing will be necessary to supplement natural reproduction in the forest, and will become a regular part of forest management in national forest work.

CONCLUSION.

Just as the greater portion of the forest area of the United States lies in the East, so the amount of land requiring restocking with forest is greater in that region. Conservative lumbering and forest planting within national forests and by private owners in the West

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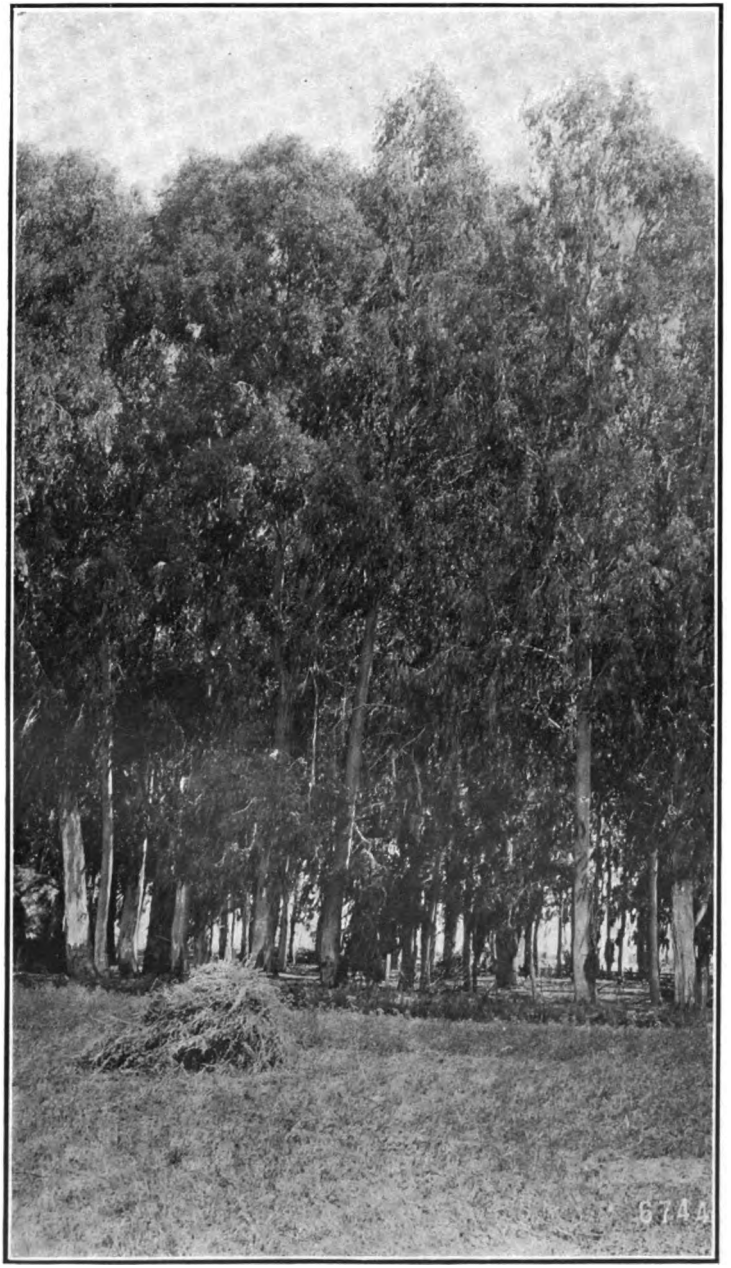

30-YEAR-OLD GROVE OF MANNA GUM (EUCALYPTUS) IN SUTTER COUNTY, CAL.

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3-YEAR-OLD BLACK LOCUST PLANTATION ON IRRIGATED LAND, IDAHO.

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will maintain a permanent supply of our valuable western conifers, but in the East the perpetuation of the best species of hard woods and conifers is dependent largely upon the activity of the private landowner. It is essential that the people of each State should realize the immense importance of individual effort in providing for a future timber supply and not depend wholly upon the results of federal or state action. The amount of land that can be restored to value through planting by the Federal Government or the States is small compared to the great area that must be forested eventually by private landowners or corporations.

TABLE 1.—*Eastern region—Northern forest.*

States.	Total area.	Area that should be planted by state governments.	Area that should be planted by United States Government.	Area of private lands that should be planted.
	Acres.	*Acres.*	*Acres.*	*Acres.*
Maine	19,132,800			181,300
New Hampshire	5,779,840			558,400
Vermont	5,839,360			444,000
Massachusetts	5,144,960			532,200
Rhode Island	682,880			50,000
Connecticut	3,084,800			500,000
New York	30,498,560	45,000		1,523,800
Pennsylvania	28,692,480	76,000		1,232,400
Michigan	36,787,200	400,000		5,000,000
Wisconsin	35,363,840	200,000		4,682,200
Minnesota[a]	25,874,560	800,000	10,000	1,617,979
Total	196,881,280	1,521,000	10,000	16,322,279

States.	Total area requiring planting.	Area of past planting by state governments.	Total area of past planting.	Area of planting plans prepared by Forest Service, 1899–1908.
	Acres.	*Acres.*	*Acres.*	*Acres.*
Maine	181,300		228	743.56
New Hampshire	558,400		865	164
Vermont	444,000		1,015	678.2
Massachusetts	532,200	1,463	21,463	1,939.5
Rhode Island	50,000		300	306.28
Connecticut	500,000	226	1,340	1,022.125
New York	1,568,800	3,450	4,450	9,150.8
Pennsylvania	1,308,400	100	4,435	5,575.24
Michigan	5,400,000		3,500	14,378
Wisconsin	4,882,200		500	656
Minnesota[a]	2,427,979	250	5,250	140
Total	17,853,279	5,489	43,346	34,753.705

[a] Fifty per cent of the State is considered in forest, and figures are based on this estimate.

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TABLE 2.—*Eastern region—Central hard-wood forest.*

States.	Total area.	Total area that should be planted.	Total area of past planting.	Area of planting plans prepared by Forest Service, 1899-1908.
	Acres.	*Acres.*	*Acres.*	*Acres.*
New Jersey	4,808,960	308,400	185	45
Delaware	1,257,600	12,450	.....	.....
Maryland and District of Columbia	6,400,640	20,100	5,000	606
Virginia	25,767,680	1,310,450	380	227.35
West Virginia	15,374,080	2,745,150	400	480
Ohio	26,073,600	627,350	13,000	481.6
Indiana	22,966,400	580,900	10,000	1,141
Kentucky	25,715,840	1,009,000	1,500	134
Tennessee	26,679,680	1,900,000	200	.....
Missouri	43,985,280	1,437,800	2,400	91.5
Arkansas	33,616,000	940,500	500	100
Oklahoma[a]	33,318,720	640,500	8,000	200
Total	265,964,480	11,532,600	41,565	3,506.45

[a] That portion of the State east of the ninety-ninth meridian.

TABLE 3.—*Eastern region—Southern forest.*

States.	Total area.	Total area that should be planted.	Total area of past planting.	Area of planting plans prepared by Forest Service, 1899-1908.
	Acres.	*Acres.*	*Acres.*	*Acres.*
North Carolina	31,193,600	927,900	3,100	387
South Carolina	19,516,800	320,490	.....	100
Georgia	37,584,000	623,760	.....	.....
Florida	35,111,040	1,175,070	150	3,000
Alabama	32,818,560	969,900	2,500	740
Mississippi	29,671,680	302,460	100	.....
Louisiana	29,061,760	140,370	2,200	.....
Texas	83,967,360	692,250	150	200
Total	298,924,800	5,152,200	8,200	4,427

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TABLE 4.—*Central treeless region.*

States.	Total area.	Area of future planting required east of ninety-ninth meridian.	Area of future planting required west of ninety-ninth meridian.	Area of future planting required on national forests.	Area of irrigated land requiring planting.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Illinois	35,841,280	.....	.....	.....	.....
Iowa	35,575,040	.....	.....	.....	.....
Minnesota[a]	25,874,560	.....	.....	.....	.....
North Dakota	44,917,120	694,463	881,260	.....	2,280
South Dakota	49,195,520	713,033	922,205	150,000	3,000
Nebraska	49,157,120	612,144	924,687	556,072	900
Kansas	52,335,360	784,941	876,285	302,387	240
Oklahoma[b]	11,106,240	.....	312,044	5,000	.....
Texas[b]	83,967,360	.....	2,505,851	.....	1,800
Total	387,469,600	2,804,581	6,422,332	1,013,459	8,220

States.	Total area that should be planted.	Area of past planting east of ninety-ninth meridian.	Area of past planting west of ninety-ninth meridian.	Total area of past planting.	Area of planting plans prepared by Forest Service, 1899–1908.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Illinois	1,456,526	.....	.....	15,568	198.58
Iowa	1,929,752	.....	.....	125,000	170.9
Minnesota[a]	1,178,728	.....	.....	115,000	218
North Dakota	1,578,003	34,937	17,093	52,030	257.62
South Dakota	1,788,238	110,462	11,563	122,025	864.53
Nebraska	2,093,803	133,541	58,455	191,996	320.99
Kansas	1,963,853	154,131	20,892	175,023	1,105
Oklahoma[b]	317,044	.....	21,143	21,143	627.675
Texas[b]	2,507,051	.....	13,169	13,169	1,724.86
Total	14,813,598	433,071	142,315	830,954	5,488.155

[a] Prairie portion of the State considered to be 50 per cent.
[b] That portion west of the ninety-ninth meridian.

TABLE 5.—*Western region.*

States.	Total area.	Total cut-over land not restocking in national forests.	Total cut-over land on military reservations.	Total cut-over land that should be planted by private persons.	Total area of forest land requiring planting.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Montana	93,296,640	434,000	.....	.....	434,000
Wyoming	62,460,160	637,000	6,892	.....	643,892
Colorado	66,341,120	932,500	.....	27,793	960,293
New Mexico	78,401,920	226,000	2,564	.....	228,564
Arizona	72,857,600	255,000	.....	5,000	260,000
Utah	52,597,760	174,000	.....	16,976	190,976
Nevada	70,285,440	.....	.....	.....	.....
Idaho	53,618,560	228,000	.....	.....	228,000
Washington	42,775,040	103,500	1,050	53,760	158,310
Oregon	61,188,480	150,000	150	89,273	239,423
California	99,898,880	1,113,500	.....	83,838	1,197,338
Total	753,721,600	4,253,500	10,656	276,640	4,540,796

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TABLE 5.—*Western region*—Continued.

States.	Total area of treeless land to be planted.	Total area that should be planted.	Total area of past planting.	Area of planting plans prepared by Forest Service, 1899–1908.
	Acres.	*Acres.*	*Acres.*	*Acres.*
Montana	358,513	792,513	500	600.6
Wyoming	249,136	893,028	1,000	.....
Colorado	262,144	1,222,437	8,000	63.3
New Mexico	158,126	386,690	3,000	5,806.55
Arizona	60,859	320,859	500	.....
Utah	107,432	298,408	1,000	50
Nevada	81,769	81,769	100	.5
Idaho	103,947	331,947	1,000	.....
Washington	203,978	362,288	500	90
Oregon	215,206	454,629	1,500	503
California	785,230	1,982,568	20,000	8,664.95
Total	2,586,340	7,127,136	37,100	15,778.9
Total on national forest	.....	.....	1,762	.....
Grand total	.....	.....	38,862	.....

TABLE 6.—*Summary.*

Region.	Total area.	Total area that should be planted.	Total area of past planting.	Number of planting plans prepared by Forest Service, 1899–1908.	Area of planting plans.	Area reported planted under advice of Forest Service.[a]
	Acres.	*Acres.*	*Acres.*		*Acres.*	*Acres.*
Eastern region, northern forest	196,881,280	17,853,279	43,346	101	34,753.705	2,672
Central hard-wood forest	265,964,480	11,532,600	41,565	65	3,506.45	458.5
Southern forest	298,924,800	5,152,200	8,200	15	4,427	173.5
Total, eastern region	761,770,560	34,538,079	93,111	181	42,687.155	3,304
Central treeless region	387,969,600	14,813,598	830,954	223	5,488.155	1,071.5
Western region	753,721,600	7,127,136	38,862	48	15,778.9	469
Grand total	1,903,461,760	56,478,813	962,927	452	63,954.21	4,844.5

[a] Actual areas planted up to July 1, 1908, according to reports by 45 per cent of the persons who were given advice and assistance.

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WATER CIRCULATION AND ITS CONTROL.

By BAILEY WILLIS, E. M. C. E.,
United States Geological Survey.

CIRCULATION OF WATERS.

The moisture which falls upon North America in the form of rain and snow comes chiefly from the Pacific Ocean. A smaller proportion rising from the Gulf of Mexico and the West Indian seas falls upon the eastern United States. A part of this precipitation returns to the air; another part flows to the streams; a third enters the ground. It all sooner or later returns to the oceans. In this great general circulation there are many short cuts and many stop-overs. Rain which falls upon the sea has taken a short cut. Snow which gathers in banks and glaciers, water which lingers in lakes, swamps, and especially in the soil and deeper recesses of rocks underground, has stopped over for a longer or shorter time. On the whole, the great body of moisture moves constantly, circulates in various forms through the air, on the earth, and through all parts of the superficial crust of the earth, and in its constant flow is the most vital element affecting the life of plants and animals. The very air itself is not more necessary than the presence of an adequate and fairly regular supply of moisture.

These vast movements of moisture transcend our control, but their effects do not. Has not man through intelligent skill converted the desert into a garden? And has he not through obstinate ignorance turned the garden into a desert? The path of our race from Asia across Europe has led through many such gardens; it is marked also by such deserts.

Says Irving in the charming introduction to The Alhambra:

> Though there are exceptions in some of the maritime provinces, yet for the greater part Spain is a stern, melancholy country, with rugged mountains and long sweeping plains destitute of trees and indescribably silent and lonesome, partaking of the savage and solitary character of Africa. What adds to this silence and loneliness is the absence of singing birds, a natural consequence of the want of groves and hedges. The vulture and the eagle are seen wheeling about the mountain cliffs and soaring over the plains, and groups of shy bustards stalk about the heaths; but the myriads of smaller birds which animate the whole face of other countries are met with in but few provinces in Spain, and in those chiefly among the orchards and gardens which surround the habitations of man.

No better description could be written, not only of Spain but of Asia Minor, where the marbles of Grecian civilization mark the sites of lost cities; or of Dalmatia, where barren plateaus have replaced the forests from which Rome built her navies; or of many other parts of southern Europe and northern Africa, where man has helped to

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rob nature of her charm and transformed her gentleness into stern severity.

We Americans have left these desert mountains behind in Eurasia; but we occupy the last land that lies toward the setting sun. Our children and our children's children for countless generations are to enjoy the gardens or bewail the deserts we create.

In the general circulation there is just one point where agencies under human control can directly affect the course of the movement. It is where rain strikes the ground or the vegetation covering the ground. From this point three routes are open to the moisture. It may evaporate, it may run off, or it may sink in. That which evaporates is lost to man's immediate use; that which runs off may be useful, but is frequently so violent as to be harmful; that which sinks in flows slowly to the springs and streams and becomes available when most needed.

Now man can send more water back at once to the air and down to the streams, or he can lead a larger proportion into the soil to enrich his crops, to feed springs, and to bear his boats during low river stages, or he can strip the ribbed rocks of soil, as witness Spain, France, Italy, Greece, and China, or he can clothe the surface with forest or verdure or thirsty fallow.

It is the object of this paper to consider the methods and efficiency of man's control, through engineering, agriculture, and forests. But before entering upon that subject we may take a general view of moisture in circulation along the several parts of the route that are commonly known as precipitation, ground water, evaporation, and surface flow.

PRECIPITATION.

Air and moistre may be mixed, as in clouds and mists, and some amount of moisture is dissolved in the air, no matter how dry it may seem. These two states of moisture in the air, whether mixed or dissolved, depend chiefly on the temperature. Changes of temperature are related to changes of barometer, and pressure has an effect on the condition. For any particular temperature and pressure the air will hold a certain amount of dissolved moisture and no more.[a]

Any effect which changes the temperature of the air makes it either more or less thirsty. A familiar instance is the cloud banner which seems nailed to a mountain top, especially to a snow peak, in spite of a strong wind. In that case a warm air current containing dissolved moisture is cooled by rising along the slope or by contact with the snow, and a part of the moisture becoming condensed is seen as a cloud. Blown further, the water particles are redissolved in warm air currents and the cloud ends; but as the conditions and changes are continuous the banner is not blown away.

A similar phenomenon may be observed over such regions as our great plains, where the column of rising air, becoming dilated and cooled, forms a rain cloud at great height, yet the falling rain is dissolved in the hot air below before it can reach the ground. No one who has seen the shower vanish into thin air will question the effec-

[a] Dissolved here means invisibly dispersed in the air. The physical or chemical nature of solution is not in point.

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tiveness of radiation from treeless plains under a summer sun to prevent precipitation.

Who does not know a drying wind? Such an one as blows cold from the Canadian snows and warming up drinks up moisture from every pore of the surface? Or if you have crossed the Cascade Mountains of Oregon or Washington you know how the wet air of the western ranges contrasts with the furnace dryness of the eastern plains. The mountains are wet because they are high, and they are heavily forested because they are wet. But there is also a reciprocal action of the forests on the wetness, for the radiation from the dark green expanse is comparatively uniform and promotes frequent and steady rains. Were the mountains bare they would, like the bared sierras of Spain, receive occasional but violent downpours and send down excessive and disastrous floods, even more disastrous than now.

On the other hand, the plains are dry because they are low and situated beyond the heights in the path of moisture-bearing currents, and they are without forests because they are dry. But here also there might be, yes, may be, a reciprocal action of vegetation on the dryness. For in so far as we clothe the surface with green crops we lower the temperature of the rising air and favor precipitation on the verdure covered plain.

Thus moisture, in pursuing the great globe-encircling routes of the winds, may be influenced by local conditions to stop or to hasten on. There is a cycle of reactions which begins with rain, is continued by ground water and vegetation, and leads back to rain. The showers sink in, the seed germinates, the plant grows in the moist soil, and the cool, moist air above the green surface provokes a shower; or the downpour dashes off, the bare surface radiates the heat of the brilliant sun, and the shower that might fall passes over.

These reactions are not the great ones, but they are effective enough in many regions to make a garden or a desert, as the experience of our race, viewed in the light of modern knowledge, proves.

GROUND WATER.

If anywhere in humid regions a well be sunk deep enough water will commonly be found. The water fills the soil or the spaces in the rocks. It flows into any opening and is governed by gravity, so that it runs down grade under ground. It is "ground water" and its surface is the "ground-water table."

In humid regions the ground-water table corresponds with the surface level of swamps and streams in their immediate vicinity, but it rises above them in uplands, following in a measure the altitude of the surface, though it does not reach an equal height. From the higher parts the ground water flows down to the lower; that is, from the uplands underground to the streams. If it be replenished by frequent rains it feeds the streams steadily. If not, the supply diminishes at first rapidly and then very slowly. It is the principal source of moderate and low-water flow in rivers of the eastern United States.

In arid regions the ground-water table usually lies at considerable depth or is wanting. Underground water may even be restricted to deep water-bearing strata, which it enters along the outcrop and in which it is under artesian head.

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In all regions, except excessively dry deserts, the soil above the ground-water table contains some moisture, which envelopes the grains with a thin film only, if the soil be very dry, but which otherwise occupies the minute spaces between the grains. This moisture does not fall or rise in obedience to gravitation, it being under control of forces due to surface tension, which exist in tubes of very small bore (capillary tubes) and similar minute spaces. These forces of surface tension, overpowering the effect of gravitation, draw the moisture upward or sideways or downward in the direction of least moisture and thus tend to establish a balance throughout the mass so far as the capillary films are continuous. If there be evaporation from the surface the moisture is drawn upward, and this is the principal effect due to capillary attraction.

In humid regions the ground water and the soil moisture are in contact. From the surface of the ground to the water table the soil is more or less moist, and if evaporation takes place the upward movement may extend down to the water table, and some part of the ground water may be drawn into the capillary circulation.

In arid regions the ground water and soil moisture are commonly not connected, but are separated by a greater or less space in which the capillary films that envelope the soil grains are not in contact and there is consequently no capillary circulation. This is true under much of the great plains. Streams are there fed only by immediate flood run-off or by underground waters from remote mountains.

Both ground water and soil moisture are derived from precipitation; the soil moisture in any area being part of the rain or snow that falls on that area; and ground water also being often accumlated from the surface which it underlies, but frequently coming from higher grounds near by or sometimes far away. This fact places in the farmers' hands the power to regulate the most vital thing in making a crop, by seeing to it that rain goes into the soil and not over it or away with it.

EVAPORATION.

When dry air passes over a moist surface it absorbs moisture from the latter. This is the simple process of evaporation, which is, however, subject to intricate relations of temperature, pressure, and humidity. Considering it as a way in which water that we want in the ground escapes into the air, we are interested to limit evaporation. This is possible by keeping the surface cool and the air above it moist, as under trees; and in sufficiently arid regions it is accomplished by covering the surface with a dry mulch, which cuts off the upward rise of moisture. The action of the woods in keeping the air and ground cool and moist is not open to question; even on the semiarid plains a wind break notably reduces evaporation from the fields in its lee; but it is held by some writers that the trees draw in through their roots and transpire through their leaves more moisture than would evaporate were the soil beneath them bare. This is true with regard to the soil reached by their roots, particularly on plains. On hill slopes it is also true, but trees so increase the amount of water stored in sloping ground, over that which can be stored in the same slope if bare, that they more than make up for what they transpire.

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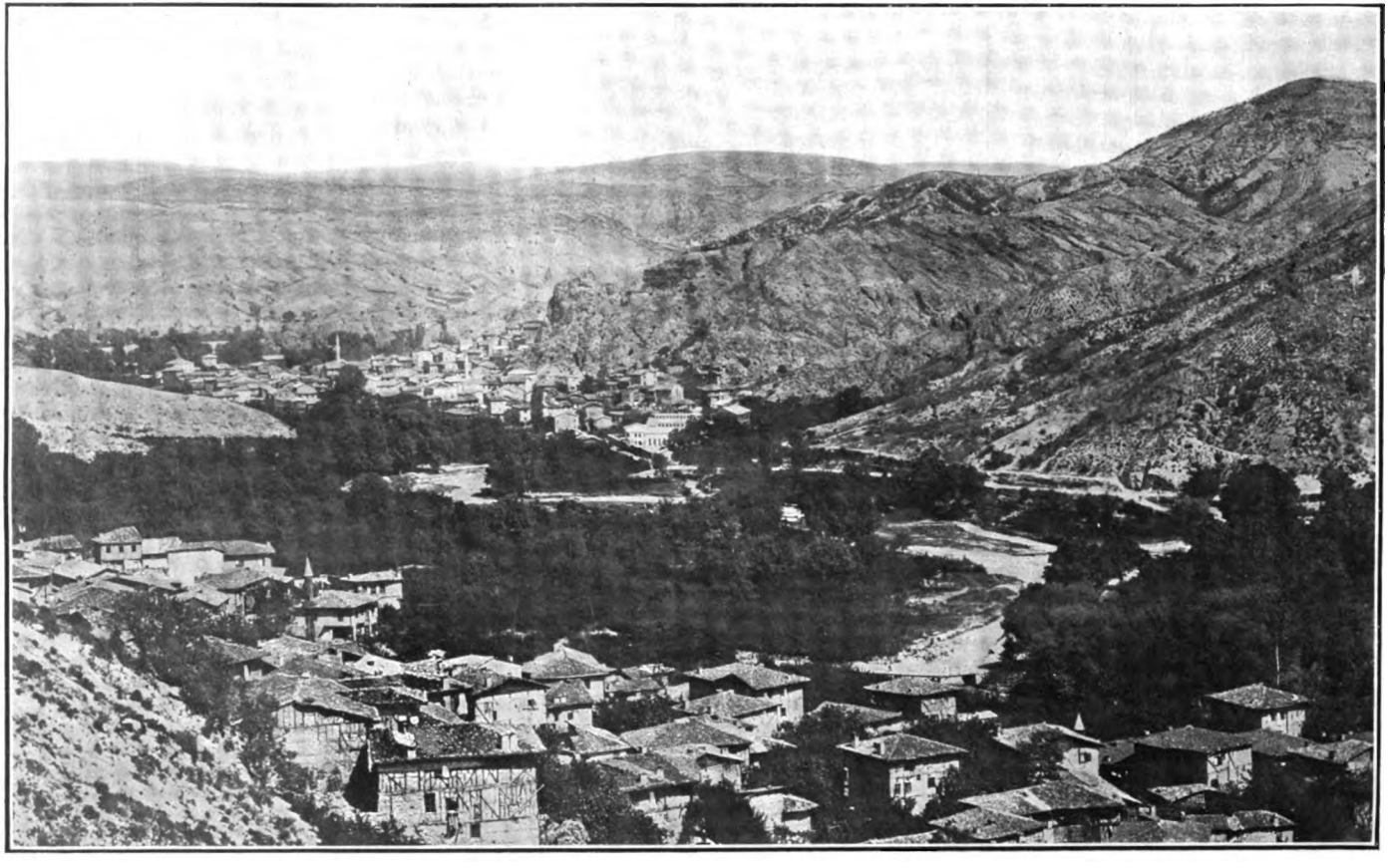

NO. 1.—ASIA MINOR. VIEW OF THE VILLAGE OF KÖPLÜ.

One hundred and thirty kilometers southeast of Constantinople, showing the deforested and completely denuded mountains. Note the areas of attempted reforestation indicated by spots in which shrubs are regularly spaced. (Photo by G. Berggren.)

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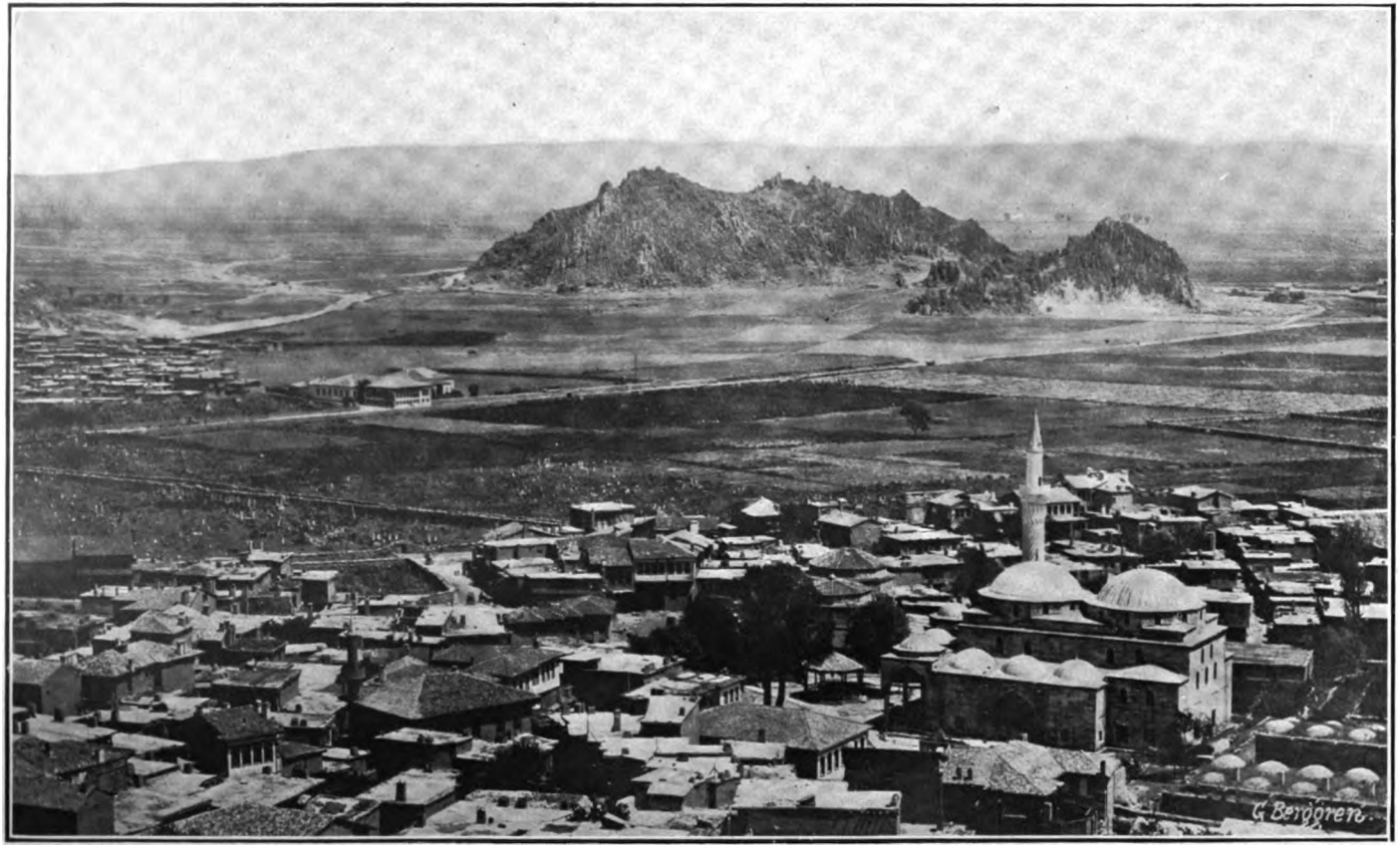

NO. 2.—ASIA MINOR. VIEW OF THE CITY OF AFIUN KARA-HISSA.

Situated about 200 miles southeast of Constantinople, in the valley of the Akkar, at an altitude of 3,400 feet (1,007 meters) above sea, showing the rocky cores of hills which have been completely denuded of vegetation and soil. (Photo by G. Berggren.)

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In regard to the manner of evaporation from soils under arid and humid conditions we may best quote as follows from Buckingham:[a]

When a moist soil dries by contact with the air above it the loss of water takes place by evaporation close to the surface, the amount lost by direct evaporation from points several inches below the surface being in general negligible. As the surface soil dries out a moisture gradient is established, and the dry surface soil draws up water from the moister region below by capillary action. If this capillary flow of water be prevented or lessened, as by the use of a mulch, the escape of water is decreased, because the evaporation has, on the whole, to take place from farther below the surface, so that it encounters greater resistance and is slower.

The flow of water in a soil which is not very wet has to take place through the thin films in which a part of the water is distributed over the soil grains. If the soil becomes very dry it is to be expected that these films will become thinner or break, the resistance to capillary flow increasing very much in either case. Hence it is to be expected that in very dry soils capillary flow will be slow.

Suppose a soil could be made so dry that no capillary flow at all would take place in it even when it was in contact with a moist soil. Such a layer of soil would act toward the moist soil below it as a protecting mulch. A soil can probably not be made so dry as to lose its power of capillary conduction of water entirely, but we may get an approximation to this limiting case.

Suppose that after a rain the soil surface be exposed to very arid conditions with a high surface temperature and a hot, dry wind. The surface of the soil will lose water much faster than it can be brought up from below by capillary action, and if the arid conditions be kept up a layer of dry soil will be formed on the surface, which may be so dry as to act in the manner suggested, i. e., as a protecting mulch. We shall thus have an initial period of very rapid evaporation, followed by a period of slow evaporation, taking place largely from below the surface.

If the same soil had been subject to less arid conditions the initial loss would have been less. The capillary flow from below would have been sufficient to prevent the surface soil from becoming dry enough to act as a mulch; hence, though the initial rate of loss would be smaller, that rate would not fall off so rapidly. It might even happen that in the long run the soil under the arid conditions would actually lose less water than the same soil under humid conditions.

From these statements and the careful experiments on which they are based it appears that in humid regions evaporation from a bare surface is not readily controlled, whereas in arid regions the precious moisture may be retained by a mulch of sufficiently dry soil.

SURFACE FLOW.

Surface flow is the water in swamps, lakes, and streams. It is all derived from precipitation, but is gathered from the surface in part only; another part appearing from seepages and springs after a trip underground. The former we will call "flood run-off," the latter "seepage run-off."

Flood run-off is that part of rain or snow fall which remains on or very near the surface, flows directly to swamps, lakes, or streams, and immediately or in a short time runs away. Following showers, flood run-off raises streams; following prolonged rains or melting snow it occasions high water, which quickly recedes when the rain or melting ceases; and following excessive rains or melting, flood run-off produces great floods.

Flood run-off is thus the most transient, irregular, wasteful, and dangerous part of precipitation.

[a] Buckingham, Edgar: Studies in the movement of Soil Moisture. U. S. Dept. of Agriculture, Bureau of Soils, Bull. No. 38, pp. 18–19, 1907.

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It damaged the people in the United States in eight months, January 1 to August 31, 1908, to the extent of $237,000,000. In the year 1907 it occasioned the loss of $118,238,000. In the ten years prior to December, 1906, it cost not less than $1,500,000,000 in goods, buildings, bridges, roads, railroads, and real estate, washed away.

These losses are net losses; they do not include deterioration of values not actually destroyed, nor do they cover the incalculable, irreparable loss of fertile soil from our mountains, grazing lands, and fields. This loss amounts to approximately 1,000,000,000 tons of soil per annum. Nor does the financial loss include the sum of human suffering or the loss to the nation through lowered efficiency and morale of the citizens who suffer from floods.

Seepage run-off stands in direct contrast to flood run-off. It is slow and gradual where the other is quick and spasmodic; it is regular where the other is irregular; it continues when the other fails. The uses of surface waters (crop growing, city water supply, sanitation, water power, and navigation) depend on reliability and regularity. Hence it is obvious that the works of man should be designed to increase that part of rainfall and snowfall which, sinking into the ground, contributes to seepage run-off, and to regulate the flow of that considerable part which can not enter the ground.

Rain falling on a well-tilled field or grass or forest largely sinks in. Falling on bare, baked, incrusted ground, it dashes off. Whichever in any place occurs, some farmer or herdsman or lumberman is responsible, for there is now no considerable part of the United States that man does not make or mar. But at the best there will always remain a notable proportion of precipitation that will form flood run-off, and this we must commit to the care of the engineer as part of the surface flow which it is his duty to control.

OUTLINE OF METHODS OF CONTROL.

ENGINEERING CONTROL OF SURFACE FLOW.

The engineer aims to regulate surface flow through methods of storage, diversion, or confinement in an established channel. His selection of method is determined by the topographic conditions of the particular locality primarily, and also by the balancing conditions of need and cost. The result is a reservoir, canal, or other structure designed to be permanent, to meet the greatest emergency which may arise, and to supply such water or afford such relief from water as conditions require. When practicable the investment should return to the people at least a fair interest on the cost. These limiting conditions are so well understood and engineering practice is based upon such a thorough knowledge of fundamental mechanical principles that in any given case the engineer's calculation may be implicitly trusted, provided that the factors of run-off, fluctuation, and sediment, which are fundamental elements of the problem, do not at any future time exceed the maximum limits which past experience leads him to assume. This provision implies that the progress of settlement and the exploitation of our natural resources should not unfavorably modify the relation of run-off to ground storage and evaporation. Through ignorance, carelessness, and greed, the farmer, herdsman, and lumberman are constantly violating this provision, as we

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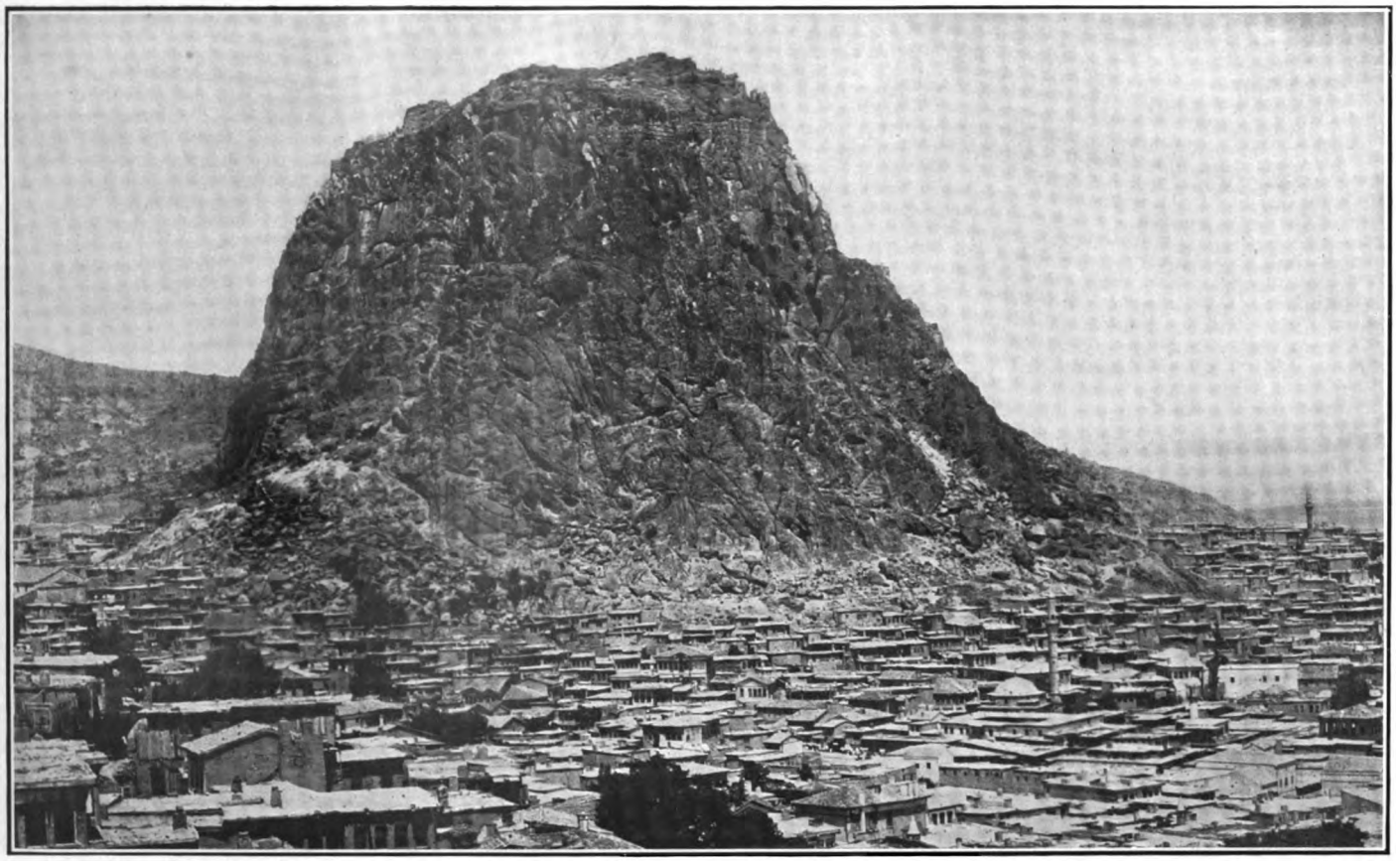

NO. 3.—ASIA MINOR. VIEW OF THE CITY OF AFIUN KARA-HISSA.

Showing the old citadel crowned by ruins. The mountain is a residual mass of volcanic rock from which all overlying strata and soil have been removed by erosion. (Photo by G. Berggren.)

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NO. 4.—ASIA MINOR. ADABAZAR.

One hundred and twenty kilometers east by south of Constantinople, a short distance south of the Black Sea, showing a bridge built by the Romans in the time of Justinian over a stream whose bed is now cultivated as a field. (Photo by G. Berggren.)

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shall see when we come to the consideration of the specific relation of their activities to the partition and distribution of precipitation. The engineer is now called upon to regulate run-off, the irregularity of which is persistently aggravated by these widespread activities; he is required to take care of sediment whose volume is constantly increased by vicious methods of agriculture, grazing, and deforestation, and the nation collectively spends millions on engineering while the people individually render the expenditure useless.

The engineer urgently needs the support of an educated, enlightened public opinion which will control individuals. In proportion as every landowner manages his property intelligently with regard to its perpetual value and the welfare of the commonwealth, the engineer's problem will shrink within those limits of reasonable magnitude and cost which it now threatens to exceed.

Let us consider some examples of the engineer's methods of regulating surface flow by storage, drainage, diversion, and canalization.

The construction of reservoirs for the storage of waters is in comparison with its possibilities very slightly developed in the United States. A few examples will illustrate the magnitude and purposes of existing works.

The Croton reservoir system cost Greater New York $86,359,562 up to 1898, and estimates on extensions and improvements are $161,000,000. The city can afford it, for the system supplies pure water to 4,000,000 persons, among whom, considering one benefit only, the death rate from typhoid fever was, in 1905, 16 per 100,000, as against more than 100 per 100,000 in certain cities supplied with polluted river water.

On the upper Mississippi a reservoir system has been gradually installed since 1880 to control high and low stages of the river for navigation. Lake levels were raised and low, flat lands were flooded. The topographic conditions were favorable and the cost for lands and improvements submerged was low. In sixteen years the Federal Government expended $1,525,000.[a]

Storage reservoirs for irrigation waters were established in the arid West by private enterprise in the early settlement of the regions, but work on a large scale began after the passage of the reclamation act, in 1902. The Reclamation Service has 28 projects in various stages of progress. They will make available for homes 1,910,000 acres, at a cost of $70,000,000, or $36.65 per acre.[b]

In any particular case the cost per acre-foot of storage capacity depends chiefly on the topographic situation, which determines the magnitude and character of the structures, and on the value of property to be displaced or submerged. In general, it costs less per acre-foot to store a large body of water than a smaller one.

The efficiency of a reservoir may be said to be its capacity to retain the water which ought to be stored. If it will hold all the surface flow of its drainage basin, less the amount used and evaporated during any time, its efficiency is 100 per cent. In proportion as it fails to do this during floods its efficiency falls below the maximum. A reservoir which will have an efficiency of 100 per cent is being built by the Reclamation Service on the Rio Grande above El Paso. It will

[a] Annual Report, Chief of Engineers, U. S. Army, part 2, p. 1439, 1906.

[b] Blanchard, C. J.: Home-Making by the Government. Nat. Geogr. Mag., April, 1908.

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retain more than the entire annual precipitation, approximately three times the surface flow of the drainage basin, and when it is completed floods which have been disastrous will be absolutely abolished.

If other conditions are alike, the efficiency depends on the amount and distribution of the waters from rain and snow melting. These vary according to broad districts. The factor which primarily determines cost, namely, the character of topographic basins which may be dammed, also varies broadly, and according to the distribution of these two factors we may distinguish at least four regions which are unlike in regard to storage possibilities.

The arid plains and basins of the West afford conditions of minimum or moderate cost and maximum efficiency for reservoir storage. The experience of the Reclamation Service has been cited.

Another region where reservoirs of moderate cost and adequate efficiency are possible is that of lakes and swamps which lie within the area covered in a recent geologic epoch by the great ice sheet. It includes parts of the Dakotas, Minnesota, Wisconsin, Illinois, Indiana, Michigan, and, in a less degree, New York and New England. In this region there are thousands of lakes, each one of which is a natural reservoir, and many more swamps, each one of which is a shallow, but practicable, reservoir site. The experience with the government dams on the upper Mississippi gives the best insight into the value of these reservoir conditions.

A third district which may be distinguished with reference to the possibilities of reservoir storage is found in the prairie States—Iowa, Illinois, and Ohio—and in areas of similar topography, population, and precipitation. In that part of those States which lies outside of the old ice limit, streams as a rule run in ravines or narrow valleys, which, however, have moderate fall and would, in many localities, afford practicable conditions for reservoir storage. The cost of farm lands and town sites which must be submerged is such, however, as to render capacious reservoirs too costly, provided any other means of control be practicable. Here the question of cost will limit the construction of large reservoirs. The lands are farmed and upon the farmer must rest the responsibility to the nation for a proper regulation of the water flow. The topographic character of the region is favorable to the construction of large numbers of small reservoirs to catch the flood run-off from nearby fields, and this item in farm equipment should become as much a matter of public interest and control as the maintenance of public roads. But the silt from badly tilled fields will render reservoirs useless unless the farmer prevents erosion. The larger factor in control must be found in improved methods of tillage and crop rotation.

A fourth district which presents special conditions in regard to storage is that of the Appalachian Mountain region. Here topographic forms are such as to render reservoir construction both difficult and expensive. The narrow valleys alone offer possible sites. Their steep gradients necessitate high dams for reservoirs of moderate capacity. Where wide bottom lands afford better opportunities, important towns are commonly located. Moreover the efficiency of such reservoirs must be low, because the flood run-off is torrential and some considerable part of it must be permitted to escape. We may not, however, conclude that reservoirs are impracticable.

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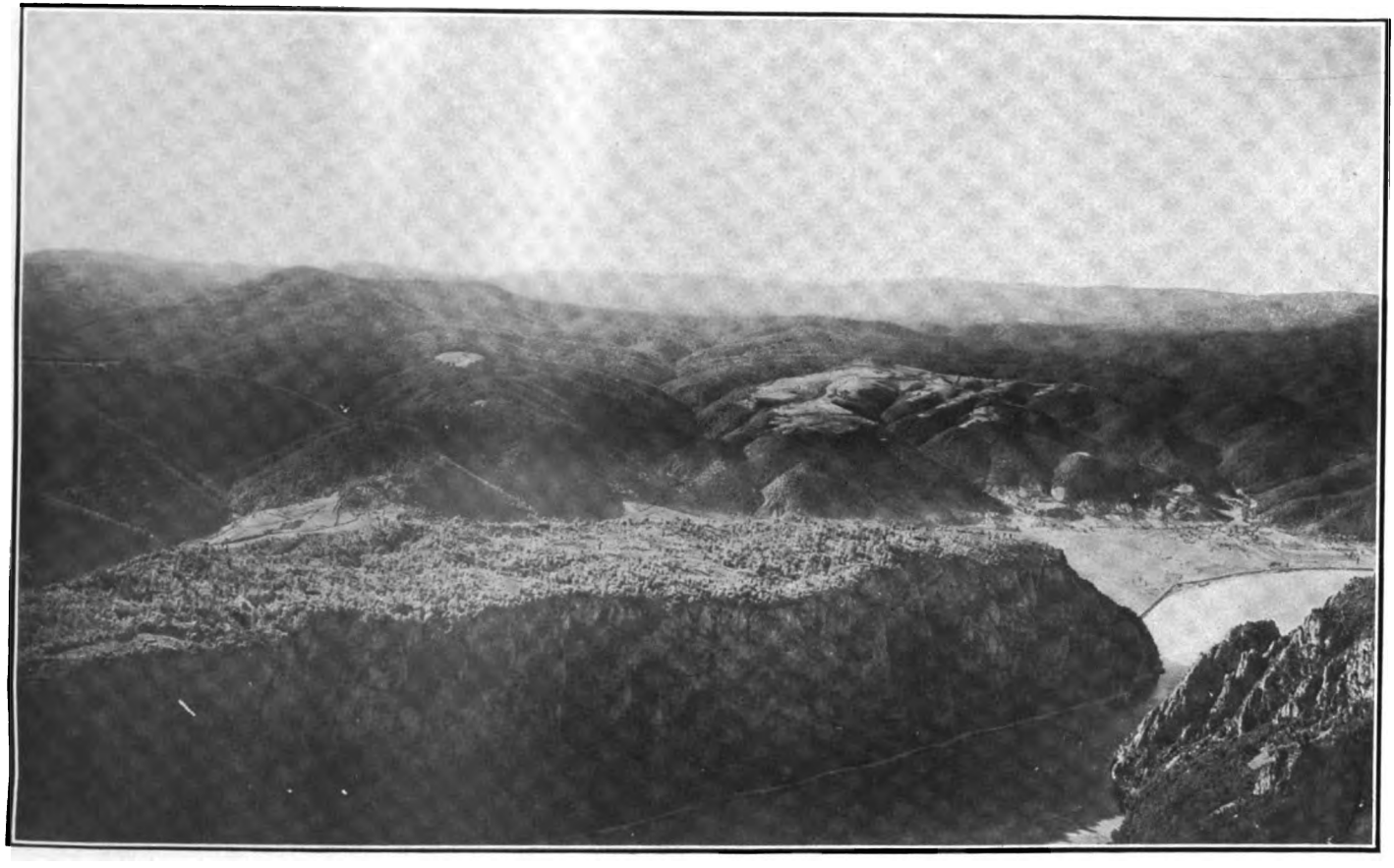

NO. 5.—VIEW AT THE IRON GATE ON THE DANUBE IN SOUTHEASTERN AUSTRIA.

Overlooking a portion of the Transylvanian Alps, which are maintained under forest cover except on gentle slopes. There is striking resemblance in topographic forms and physical conditions to those of the Appalachian Mountains south of Pennsylvania. (Photo by B. W.)

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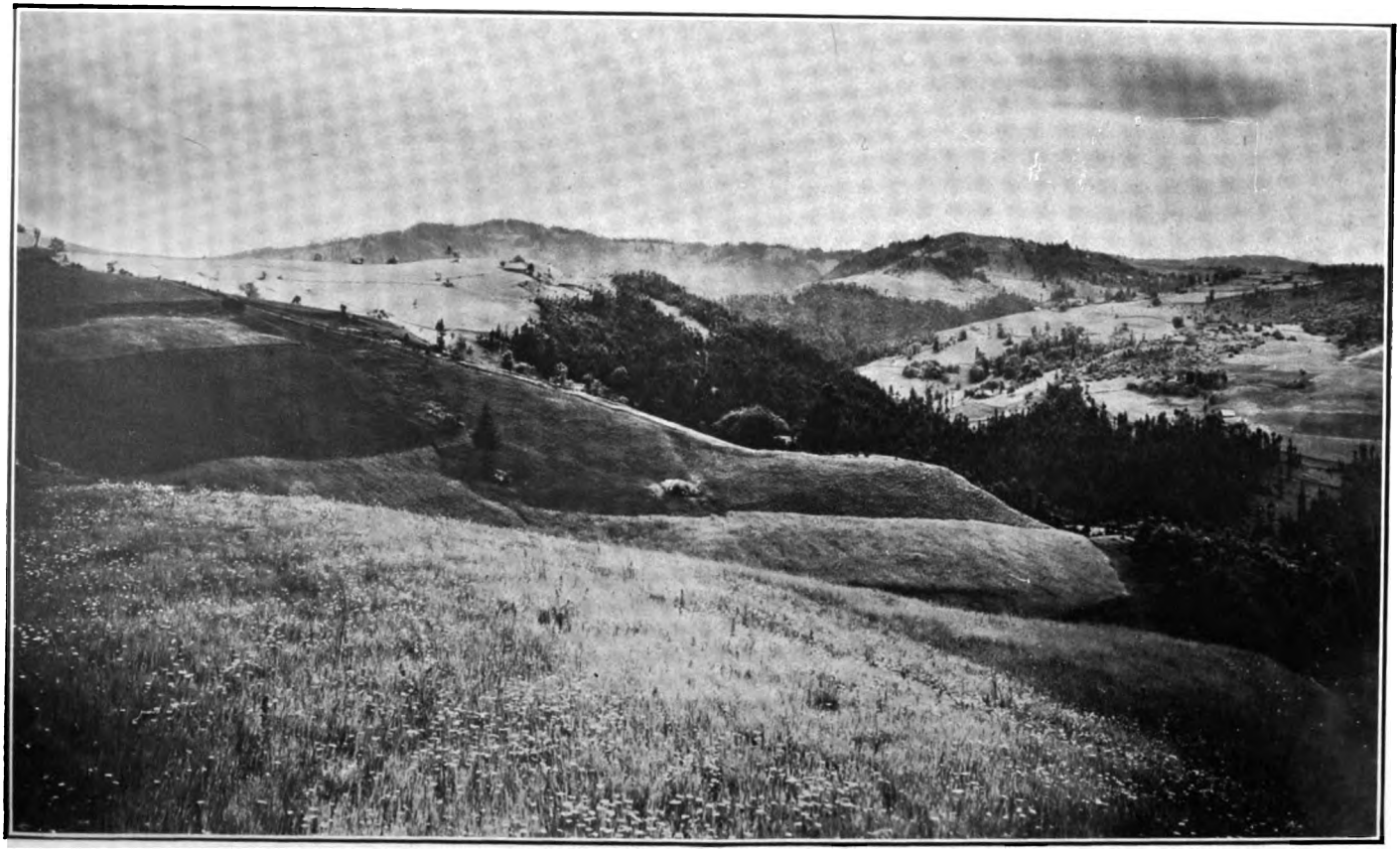

NO. 6.—AUSTRIA. VIEW IN THE NORTHERN CARPATHIANS NEAR NEU SANDEC, ON THE HEADWATERS OF THE DUNAJEC, AT AN ALTITUDE OF ABOUT 3,000 FEET.

A region in which forests have been properly cared for and exploited, and in which the slopes are carefully protected by covering of forest or grass with proper attention to methods of culture that prevent erosion. The field on the left is being cultivated. It may be noted that the furrows are all strictly horizontal. (Photo by B. W.)

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The Appalachian Mountains have always had and will always have special relations to national development. Their mountain wall guarded the colonies during a century of French and Indian warfare. Eventually occupied by American enterprise, the region became through its resources in minerals, lumber, and water power a dominant source of national strength and wealth. It can never support a large agricultural population, yet the mountain dwellers will cultivate their fields in its upland valleys so long as the soil remains. Its mineral wealth will certainly be exhausted, but its forests and streams, those two intimately related and most valuable factors in the nation's prosperity, need never be impaired though continually used.

These mountains possess a power to do harm which is not less than their power to confer benefit. The floods that gather from their rills traverse the richest cities, manufacturing districts, and valleys, and exact annually an enormous tribute. The cost in dead loss, in lessened values, and crippled industries will eventually force the nation to protect itself. There are men—engineers, too—who believe they can fetter the full-grown flood, but the Commonwealth which trusts to them alone and neglects the agencies of forestry and agriculture that divert the raindrops will suffer till it has bought wisdom dearly.

Thus throughout this mountain region the problem of controlling surface waters is not only particularly difficult, but its solution is peculiarly important. The engineer has here a grave and difficult task to perform, and even under the unfavorable local conditions the storage reservoir must take its place as one of the features of the system of regulation.

In our general discussion drainage is next. It stands in direct contrast to storage. It promotes quick discharge, increases flood run-off, and dries up swamps that storage would convert into reservoirs. No region from which injurious floods gather should be drained, for the drainage system will increase the floods. On the upper Mississippi, for instance, we would not drain the reservoirs produced by artificial dams, nor should we drain swamps that empty into them or into the river below them without duly considering to what extent our left hand is undoing the work that our right hand has done.

Yet drainage has its place in the national management of surface waters. It is appropriate in lands liable to overflow and which may safely be permitted to return the waters promptly to the stream as the river falls. It is permissible in lands whose value when drained exceeds the value of lands that the drainage waters may submerge. Here, as indeed generally, throughout this whole question of conservation the resulting value determines whether or no the thing should be done.

Diversion canals are designed to take a part or all the water of any system and conduct it from the channel in which it may be wasted or become harmful to the point where it shall be applied to some useful purpose. A mill race is a diversion canal on a small scale, and the Chesapeake and Ohio Canal, which diverts a part of the waters of the Potomac to a channel where they may be useful to navigation, falls in a similar class. In connection with the irrigation projects of the Reclamation Service, diversion canals constitute

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an important feature. In some instances they lead directly from rivers which are capable of furnishing sufficient water at all stages; in other instances, they lead from reservoirs where water is stored to maintain the desired flow when the tributary streams would be inadequate to the purpose. In none of these cases has the diversion canal any special relation to the conservation of water. It introduces a siding in the general through route of circulation and discharges its water freight at the point where it is wanted. It serves in some measure to regulate surface flow, but that object is subsidiary to a major purpose, which may be power or irrigation or navigation.

Canalization is a method of river control which consists in reducing the river to the condition of a canal by the introduction of dams, locks, and sluice gates. The current of the open river is then replaced by slack water. The discharge is permitted through locks as required by passing boats, or over sluiceways when the volume of flood run-off becomes greater than the amount which can be safely stored in any reach of the river between dams. The most important project for canalization is that of the Ohio River, concerning which we may quote from the report of a board of army engineers, dated December 15, 1906.[a]

The board finds—

> that a 6-foot navigation at low water can be established in the Ohio River from Pittsburg to Cairo by the construction of 45 locks with movable dams, at an estimated cost of $50,962,266, in addition to funds heretofore appropriated and authorized; that a 9-foot navigation over the same length of river can be established by the construction of 54 locks and dams, at an estimated cost of $63,731,488. * * *
>
> The board gives exhaustive consideration to the question of present and probable commerce, both down stream and up, and it appears that the present commerce of the river is approximately 9,000,000 tons per annum, of which a large proportion is downstream. Having in view the fact that a canalized river offers an upstream navigation lower in cost and quicker in transit than an open-river project, the board, arguing from the known natural resources of the section and its population, concludes that a river improved by this method will afford facilities for the cheap exchange of mineral, agricultural, and manufactured commodities, which from their low value and bulk can not be exchanged unless such cheap facilities are offered, and that there is every probability that the improvement of the Ohio River by canalization, as proposed, would induce a very large future commerce, which does not now exist, in addition to retaining and greatly facilitating and cheapening the commerce which the river now bears.

In discussing the maintenance of the 9-foot project, the board estimates it at $800,000 per annum, not including the dredging of silt, which would accumulate in slack water, or at $1,000,000 per annum if this item be included.

This project, which was reviewed and recommended without qualification by the Board of Engineers for Rivers and Harbors, in a report dated October 18, 1907, has for its object the single purpose of promoting inland navigation, and it illustrates clearly the relation which any plan for canalization of a stream bears to the general problem of water circulation. The plan deals with the water after it has reached a navigable river, when it is no longer a question of control of surface waters, but merely one of more or less effectively regulating their distribution and flow. The delay which may be imposed by storage in slack-water basins is not an appreciable factor

[a] 60th Cong., 1st sess., H. R. Doc. 492.

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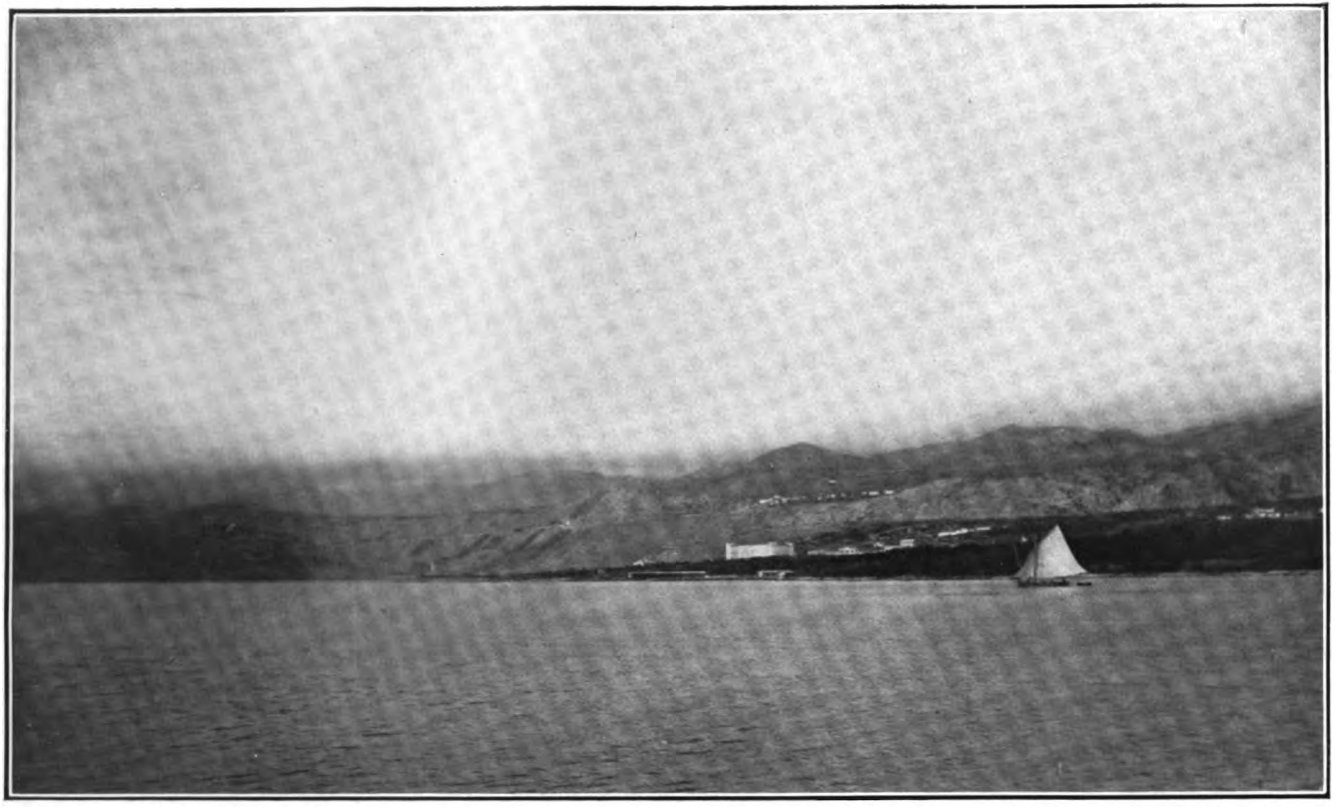

NO. 7.—DALMATIA, THE EASTERN COAST OF THE ADRIATIC.

The district from which the Romans built their navies. The dark areas consist of underbrush and small trees. (Photo by B. W.)

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NO. 8.—DALMATIA. VIEW FROM THE DEFORESTED MOUNTAINS LOOKING DOWN ON THE ADRIATIC.

When forested these mountain slopes were covered with a deep soil which hid the limestone rocks that now protrude through the thin grass. (Photo by B. W.)

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in reducing the damage due to floods such as those which now annually work havoc in the Ohio Valley. Moreover, the project itself establishes interests which lie within the zone liable to flood, and in proportion as it is successful and such interests grow in value, so grows the necessity for diminishing and preventing floods. Thus canalization bears the same relation to plans for conserving and controlling water circulation that any concentration of civilization bears to it. It increases the burden of responsibility for proper measures of control, whether in detail as applied to raindrops or in gross as applied to flood run-off, and the larger the wealth to be protected the greater the justification for large expenditures on account of protection; but more than this, for it is not a question of engineering and financial expense alone, the larger the national interests involved the greater the individual responsibility of every patriotic citizen to his local community and to the commonwealth in general for a proper discharge of his obligation to take care of his share of the nation's assets.

CONTROL OF GROUND STORAGE AND RUN-OFF THROUGH AGRICULTURE.

On a reasonable estimate one-half of the domain of the United States must eventually be farmed to maintain the population and prosperity of the country. The essential characteristic of the great farming area, exclusive of irrigation districts, is that it shall have soil and sufficient rainfall. Rain falling on soil is partly stored as ground water, but also partly runs off. The stored water is absolutely necessary to the farmer's prosperity, which will increase as he increases ground storage; the other is wasted, and if it causes erosion is destructive.

In considering the relation of the farmer's activities and the methods which he can employ to increase ground storage and decrease erosion we must distinguish between lands that are level or nearly so and lands that have a more or less pronounced slope.

Water control on plains.—In regions of great plains or plateaus, where lands are level or nearly so, the methods which may be used by the farmer to increase ground-water storage are the methods of good tillage which at the same time yield the largest crops. They consist in deep plowing, proper cultivation during the growing season, crop rotation, and the maintenance of an open condition of the soil during periods of fallow. The object of these methods is to increase the capacity of the soil reservoirs and to open and keep open the channels through which the rain or melting snow has access to them. Run-off and erosion are restricted in proportion as this aim is secured.

To grow large crops takes a large amount of soil moisture. The soil gets it directly from rains or in seasons of drought from the ground water which is supplied by rains that pass down through the soil to the water table. The rain that soaks in is stored for the crop. The rain that runs off is taken from what might be stored, and is not only lost but, being muddy, is also lost soil. Good tillage reduces these losses by maintaining those conditions of soil and subsoil under which a large proportion of a given rainfall will be absorbed.

In general, we say that an open soil will absorb most water. The openness of texture of a soil depends upon the sizes of the particles of which it is composed and the relative numbers of particles of these

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several sizes—that is, its mechanical composition. There is for any kind of soil a state at which it is in the loosest and best physical condition—that is to say, a state of arrangement of soil particles according to size and spacing in which there may be the largest amount of water gathered about the particles as capillary films and between them in delicate columns. The condition is one which is well known to farmers as that which will yield the best crops. This mechanical condition of the soil is reached by plowing, harrowing, and cultivating when the soil is neither too moist nor too dry.

The facility with which rain enters a soil depends upon its being in the above-described condition—open, yet not too open. The films of water within it are then of such size and are so distributed that they support the open texture. When rain falls it enters each little capillary tube between the grains and penetrates rapidly in the many minute channels. Thus the soil, though moist, absorbs more water than if it had been drier to begin with.

When soil is very dry and powdery rain does not penetrate far into it. There are several conditions that produce this well-known result. Much water is used in filling the large volume of the small spaces between the soil grains; the capillary films are still separate at the bottom of the sinking moisture and they sink deeper only as they join, and the air in the soil, being imprisoned by the water that fills the upper layer, offers effective resistance to percolation.

The absorbent character of a soil determines the amount which the immediate surface will take in, but it does not determine the rate at which water will soak into the lower layers of the soil and subsoil; if the latter is impermeable, the pores of the surface soil may become so filled that no more water can enter, and the rest of the rain runs off. This happens when a heavy rain falls on a field that has been plowed only 3 or 4 inches deep, leaving an unbroken clayey subsoil. If the field is level, pools of water will stand over it till they dry up. If the field be on a slope, the gathering water runs off along and across the shallow furrows and takes more or less soil with it. Where the subsoil is broken to 12 or 14 inches by deep disk plowing the same heavy rain sinks in completely and is stored for the crops when needed. The soil also stays.

Thus on plains the conditions which affect percolation of rain into the soil and subsoil and which are consequently to the advantage of ground-water storage are—

(*a*) That the cultivated surface shall be level or but gently sloping;

(*b*) That the surface soil shall be in that condition which is best described by the gardener's term of "live soil;"

(*c*) That the lower soil and subsoil should afford the largest possible amount of space into which the water from the surface may run.

Another means which is at the farmer's disposal is that of crop rotation. Clean cropping year after year exhausts the plant food and humus of the soil, affects unfavorably the mechanical condition of the soil, and brings it into a state in which its fertility is greatly reduced and it is most easily eroded. In order that these effects should be prevented it is important to introduce a rotation of crops, including grass or clover, whose deep and thickly matted roots help to open up the texture of the soil and to restore that essential constituent, humus.

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NO. 9.—DALMATIA. EFFORTS TO REFOREST THE REGION DENUDED DURING ROMAN OCCUPATION AND LARGELY ABANDONED TO EROSION DURING THE CHRISTIAN ERA. (PHOTO BY B. W.)

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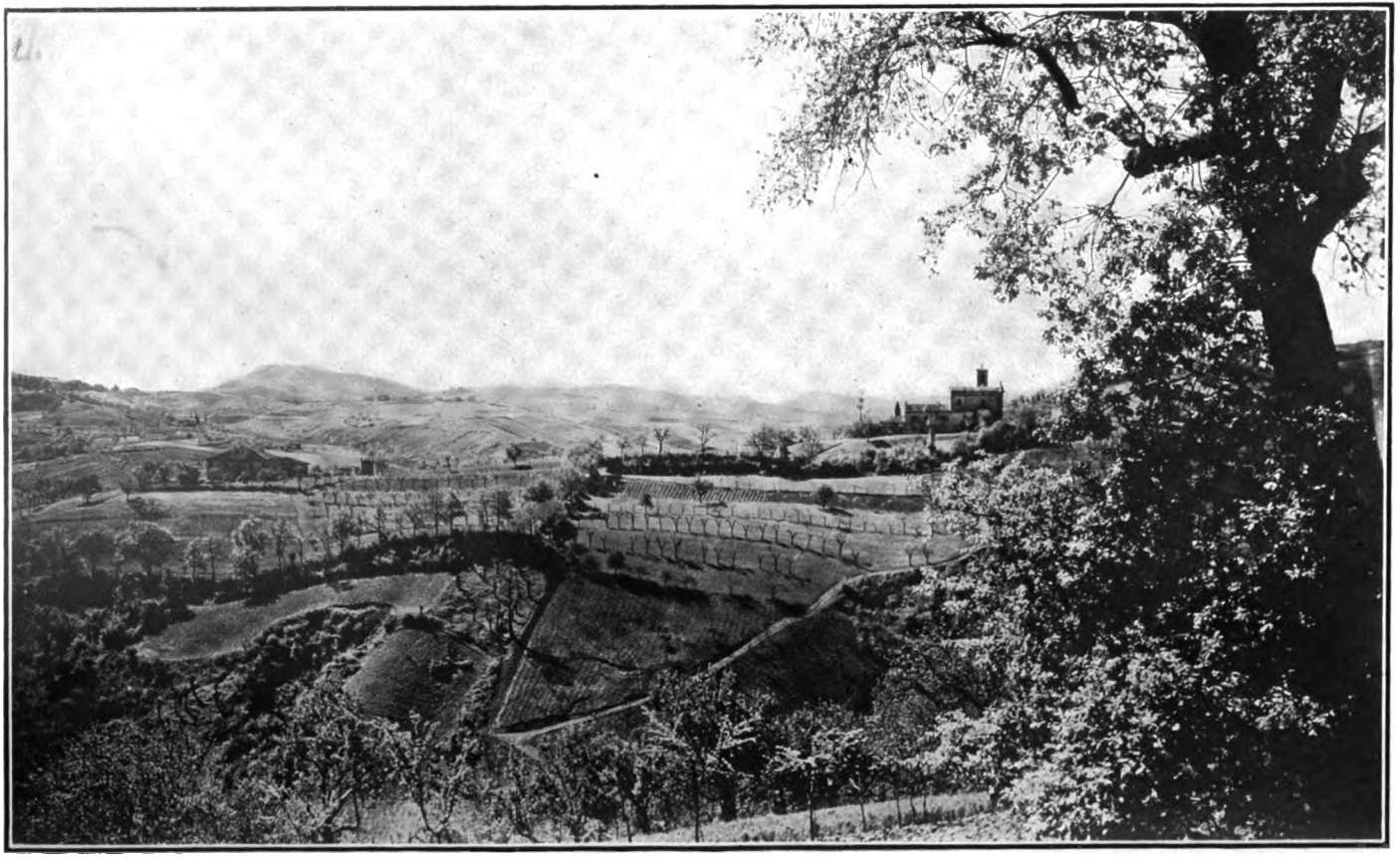

NO. 10.—ITALY. NORTHERN SLOPES OF THE APENNINES, NEAR BOLOGNA.

View showing the general absence of timber with extensive cultivation of all gentler slopes. Care is taken to prevent the development of gullies, and erosion is checked so far as practicable under the conditions of use of the land for agriculture. (Photo by B. W.)

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We have thus far considered only how the farmer can produce a condition of the soil and subsoil which will reduce run-off and increase ground storage. It is also important when the water is in the ground to keep it there, except as crops need it. It should not be wasted by useless plants nor by evaporation.

The waste by weeds is obvious. A growing weed takes water which the useful crop might have. The remedy—keeping out weeds—is equally obvious and is limited simply by cost.

Evaporation exhausts ground water most effectively when there is free circulation from the ground water to the surface. This happens when the films of water about the soil grains are in contact and there is ready movement in them. As the water immediately at the surface is vaporized, an additional supply is drawn to the surface through the capillary films from below. This is evaporated in turn and more is drawn up, and so through evaporation and capillary attraction the soil moisture is gradually dissipated into the air.

That condition of dryness which stops the upward movement of ground water by breaking the continuous water films is not readily established in humid regions, where the ground water lies not far below the surface and rains are not infrequent. Thus it appears that since in humid regions the farmer can not effectively restrict evaporation, he must resort throughout the entire year to every method of cultivation, and from year to year to the method of crop rotation, to keep his ground in the best possible condition for the largest storage of ground water, from which will follow also the largest return of any one crop. In the arid region nature comes to the aid of the farmer and gives him a means of stopping the loss of the precious moisture of which under the best conditions he can scarcely conserve enough.

When the farmers of America understand how to store and keep water in the ground they will have learned how to grow larger crops. Our average yield of wheat instead of being as it now is 14 bushels to the acre will then be nearer the average yield of Great Britain, 32 bushels.

Water control on slopes.—In regions where steep slopes are cultivated the methods appropriate to level fields find their application also, but they are insufficient, for the tendency of the water to run off lessens the time of its contact with the surface, and thus increases the proportion which escapes at the expense of the proportion that is stored. In a like degree erosion begins and is maintained on slopes, the soil is undercut and removed, and the subsoil or rock exposed. Forests would prevent this, but if the steep slope is cleared for cultivation it is necessary to substitute a series of steps for the smoothly inclined surface, in order to reduce these effects to a minimum.

This introduces a condition which is not yet necessary in America to any great extent, but which is general throughout Europe and Asia, namely, terracing. The object is to catch rain and snow on a level. The level may be the furrows of a plow or of a harrow, provided the slope be so gentle that these suffice to hold back the water and prevent it from running and gullying the fields. On steeper slopes the harrow and the plow are inadequate, and the farmer is obliged to introduce low steps or terraces which vary in character from a little bank of sward to walls of stone. The fields above the

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banks of sward or above the stone wall are carefully leveled and the water which falls upon them is retained. Agriculture is thus extended not only over far-spreading plains and lowlands, but up the steep banks of river gorges and ravines. The famous vineyards of the Rhine are planted on rock wall terraces, on steep slopes such as we abandon to erosion. As our population increases and the demand for agricultural land becomes more urgent we, too, will build terraces, and high river banks throughout the humid regions will grow special products. Land hunger will eventually force us to it—not soon, however—and in the meantime our steep cleared lands can not be left a prey to erosion. They must be recovered where gullied and must be protected from gullying by watchful care, such as that which guards Holland from the sea. Our enemy is no less dangerous, not a whit less insidious and persistent. Since terracing is a possibility of the future only, we must restore the forest trees. They have held the soil during ages and in them we can confidently rely.

We are wont to think that reforestation is a need of high mountains only, but the need is not thus limited. It extends to all steep cleared slopes. Thousands of miles of these stretch along our rivers, from Georgia to Maine, from Mississippi to Minnesota. Throughout the humid region they border every river. Along all their length, in all their ramifications that penetrate the richest agricultural districts, they must necessarily be covered by trees.

From the plains and gentle slopes appropriate to farming there rise in all hill and mountain districts steeper slopes that are not appropriate to farming. When farmed they are quickly eroded and destroyed. It may be set down as an obvious economic principle that no land is appropriate to a use which destroys its usefulness. This principle is not affected by the fact that ignorant persons clear and cultivate such land extensively. In the southern Appalachian Mountains it is commonly but five years from virgin forest to abandoned fields. The mountain slopes are not agricultural lands. Themselves destroyed by erosion, they damage other lands and the water courses below them. When that damage is assessable by law upon the ignorance that causes it, agriculture will be restricted to appropriate fields.

CONTROL OF RUN-OFF THROUGH GRAZING.

About 25 per cent of the area of the United States is so situated with reference to topographic and climatic conditions that it will best raise hardy grasses and must be devoted chiefly to grazing. The principal area is that of the great plains, extending from northwestern Montana around the base of the Rocky Mountains to Texas, but including also portions of the basin region on the west. Within this area the governing condition is a meager precipitation. The soils are appropriate to agriculture, the mountain ranges above the plains are suited to forestry, but both agriculture and forestry require more water than the grass that feeds herds, and they are accordingly limited in distribution in this region. The herdsman's prosperity depends absolutely upon the grass. It is proved beyond dispute that overgrazing injures the grass, partially removes the protective cover, and promotes erosion. Erosion eventually results in the removal of all herbage, produces bare, gullied badlands, and makes restocking with grass impossible.

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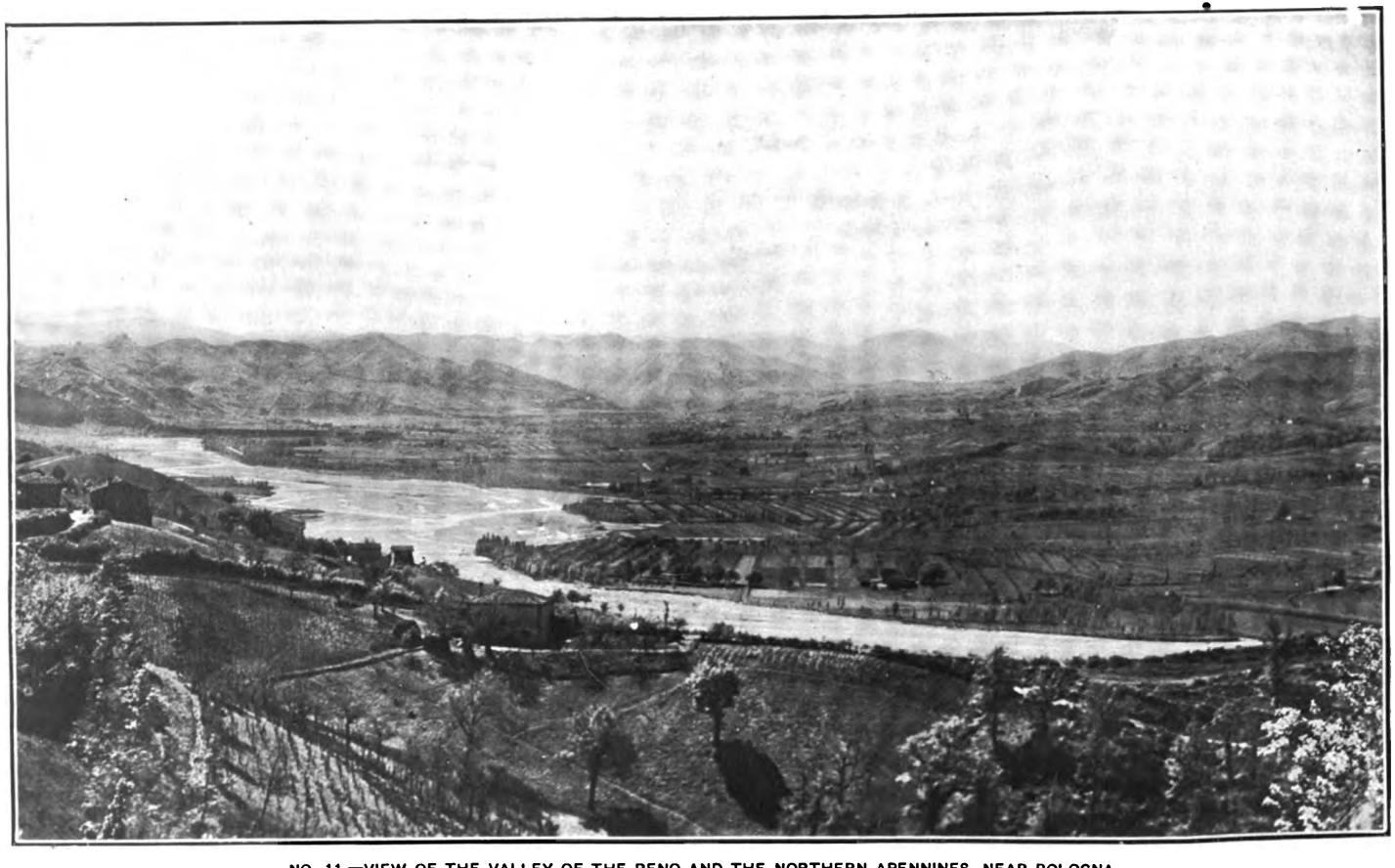

NO. 11.—VIEW OF THE VALLEY OF THE RENO AND THE NORTHERN APENNINES, NEAR BOLOGNA,

Showing the shallow meandering river among the sand bars that are composed of wash from the deforested mountains. (Photo by B. W.)

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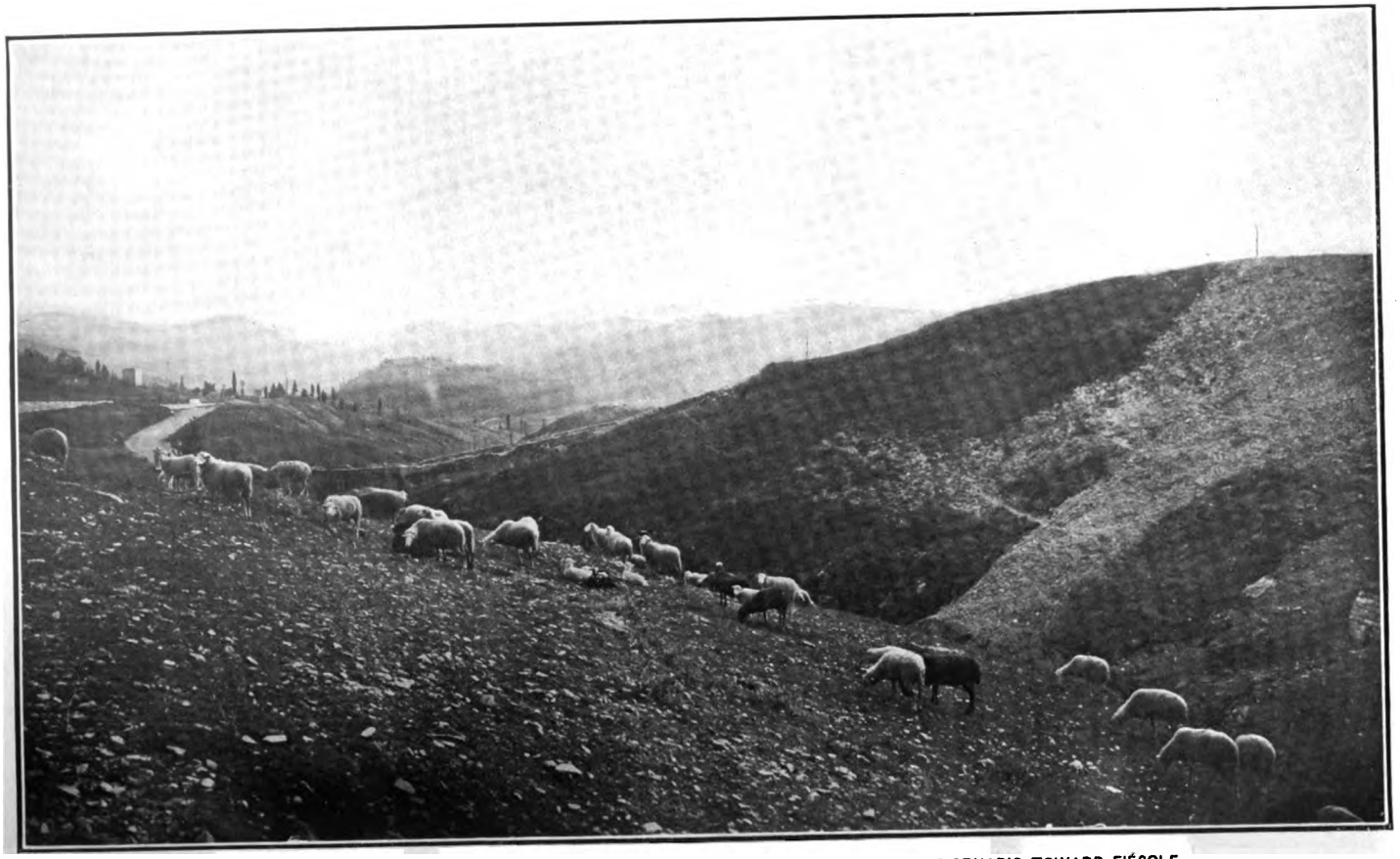

NO. 12.—ITALY. VIEW IN THE APENNINES NEAR FLORENCE, LOOKING FROM MONTE SENARIO TOWARD FIÉSOLE.

Showing the denuded hills, the shallow, stony soil which remains after the loam has been washed away, and the sheep whose grazing removes the slight protective cover of vegetation and promotes the final process of erosion. (Photo by H. W.)

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The method available to the herdsman for the limitation of run-off and the prevention of erosion is to increase the stand of the natural grass cover, upon which alone his herds depend. In some small areas he may find it necessary to adopt the usual methods of agriculture to check erosion, establish soil, and re-cover the surface with grasses, but in general that which any intelligent herdsman does to maintain the range upon which his herds live is that which he must do to prevent erosion and to limit run-off. Thus intelligent grazing promotes both individual and general welfare.

The preservation of grass upon the semiarid plains is of vital interest, probably, to the farming States, Minnesota, Iowa, and Missouri, and even more so to eastern Nebraska and Kansas. If it be true, as stated in the opening discussion of conditions of precipitation (p. 688), that radiation from the hot plains checks rainfall, it would follow, should they be eaten bare and eroded to badlands, that the semiarid climate would extend eastward. The plains themselves would become more arid, the farming districts adjoining them would be affected by prolonged droughts, and the climate would be unfavorably modified as far east as the western margin of the moist-air currents that flow north from the Gulf. Iowa is interested in the grass that grows in western Nebraska.

FOREST CONTROL OF PERCOLATION AND RUN-OFF.

The areas which must be kept forested in North America comprise 26 per cent of the whole continent. Of the United States 19 per cent requires forest protection or will grow trees more profitably than any other crop. The necessity for this amount of forests rests on two imperative economic conditions, (1) the value of forest products, and (2) the protection forests afford to other essential needs and activities of civilized communities.

It is not proposed here to discuss forest products, except to point out that their value maintains forests in areas where agriculture might be pursued if the forest products were not more valuable than the possible agricultural products. The distribution of forests, considered with reference to their products, is wholly one of cash returns. On this basis alone, however, the percentage area now left us can not economically be reduced until the increasing population begins to feel a scarcity of grain. The present price of lumber, the search for substitutes, and the coming timber famine sufficiently prove this.

Forests protect all civilized activities that depend on a regular supply of clear water or that are liable to injury from irregular and excessive flood run-off. They are not the only protecting agency. We have discussed the very great importance of engineering and good tillage in this respect. But wherever they grow forests do protect, and they do grow and protect where no other agent economically can.

This truth is challenged, for we inherit the habit of the ax and the saw, and the effects of our reckless use of these tools are not yet so conspicuous as to be clearly distinguishable in the gross result of natural and artificial activities. The challenge can not stand, however, against any fair consideration of the relations of forests and water in contrast to those of bare slopes and water.

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In the opening pages of this paper we considered those phases of water circulation that are known as precipitation, ground water, evaporation, and surface flow. Forests affect each one of these, and each will be discussed in turn in the order named, so that we may clearly distinguish the several aspects of controverted points.

Forests in relation to precipitation.—Precipitation consists of rainfall, and in cold climates of snowfall, also, and these two kinds of precipitation are differently affected by forests. Concerning forests and rainfall, unqualified statements have led to exaggeration and contradiction by which the real facts are obscured. When a vast plain like the upper Mississippi Valley from St. Louis to the Great Lakes is cleared and brought under cultivation, no notable change in the amount of precipitation is likely to follow, for the air currents which sweep over it come from the Pacific and from the warm humid atmosphere of the Gulf. They are loaded with moisture and are driven north toward cooler zones. Rain falls from them inevitably, in spite of any minor effect of radiation from the fields of Illinois or Ohio. Were the wide surface stripped of green and soil and left a region of rock and sand, as central Asia was,[a] then local radiation would doubtless increase the irregularity and violence of rains, but the air rising from our fields of grain, though not as cool as that above a forest, is not so heated as to materially affect the powerful rain-bearing currents. Moreover, the general evenness of altitudes and uniformity of radiation from the green covering over a wide area tends toward regularity of conditions and gradual rather than violent changes. The ocean of green, whether of trees or grain, ameliorates the climate in like manner, though not in like degree, as does an ocean of water. Hence it is reasonable to expect that the total precipitation and the run-off, as indicated by stream gages on rivers fed from this region, will not show any decided change as a result of deforestation. This appears to be the fact, though careful observations of rainfall and run-off have been too recently begun and are made at stations too far apart to give satisfactory data for comparisons.

Deforestation of a mountain range presents a different case, since in the long run it results in extensive erosion and bare surfaces. Leaving this last statement to be discussed under Erosion, we may compare rainfall on wooded mountains with that on barren ranges on the basis of extended human experience. The mountains of southern Spain, the Pyrenees, the Basse-Alps of southeastern France, the northern Apennines, the Dalmatian and Grecian hills, have all been stripped and eroded. The change from green-covered slopes to brown bare steeps has been accompanied by a change from beneficent rains to destructive downpours. Statistics of precipitation in earlier times are not available for comparison with those of the present, but historical evidence is entirely adequate to prove that deforestation of a mountain range has modified the conditions of precipitation in such a manner that occasional heavy destructive rains replace gentle and more frequent showers, at least in the countries mentioned.

These countries differ from northern Europe in a measure as the semiarid region west of the one hundredth meridian in North

[a] Pumpelly, Raphael: Relations of Secular Rock Disintegration. Am. Jour. Sci., vol. 18, Feb., 1879.

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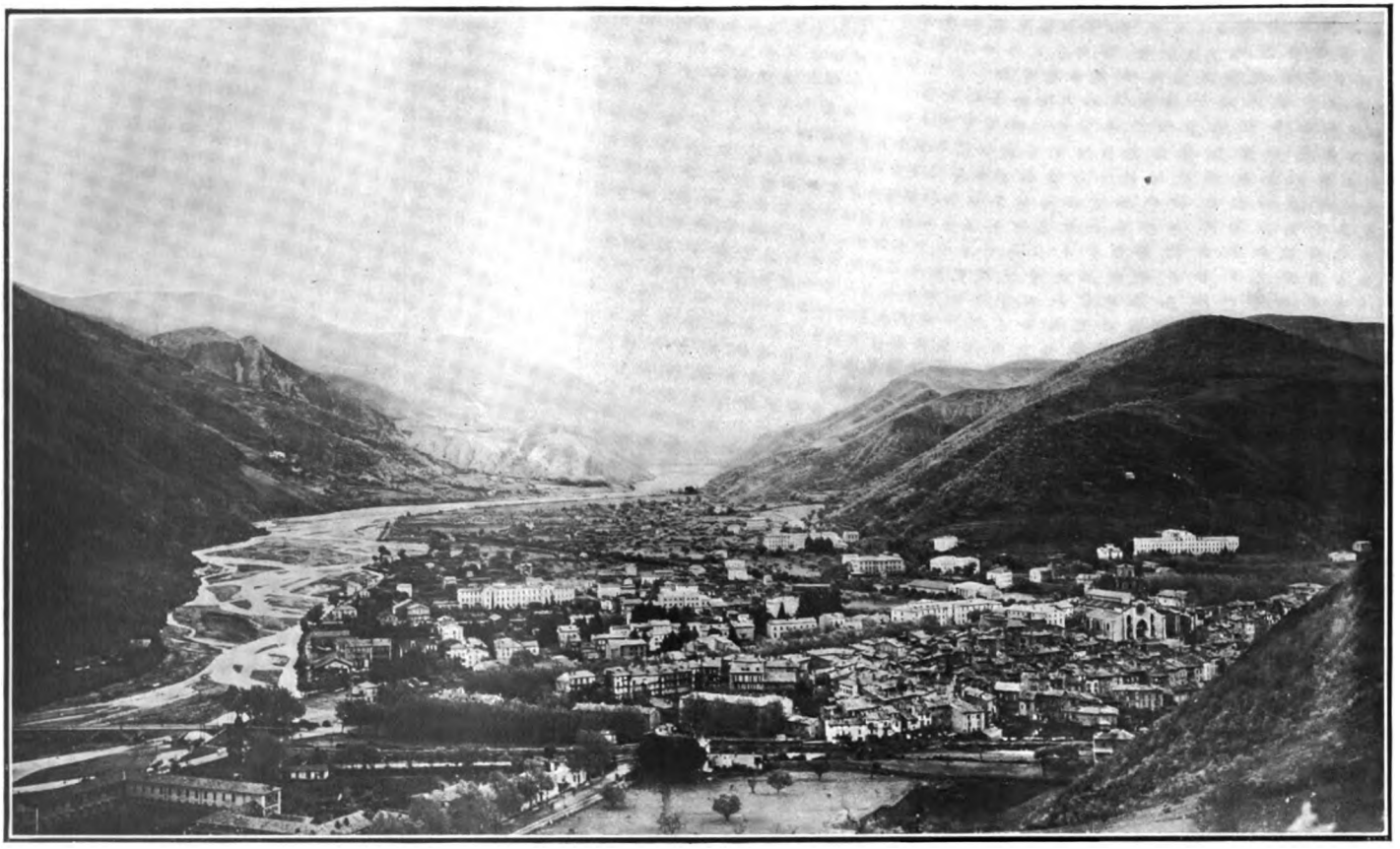

NO. 13.—FRANCE. VIEW OF DIGNE IN THE VALLEY OF THE DURANCE. (PHOTO BY B. W.)

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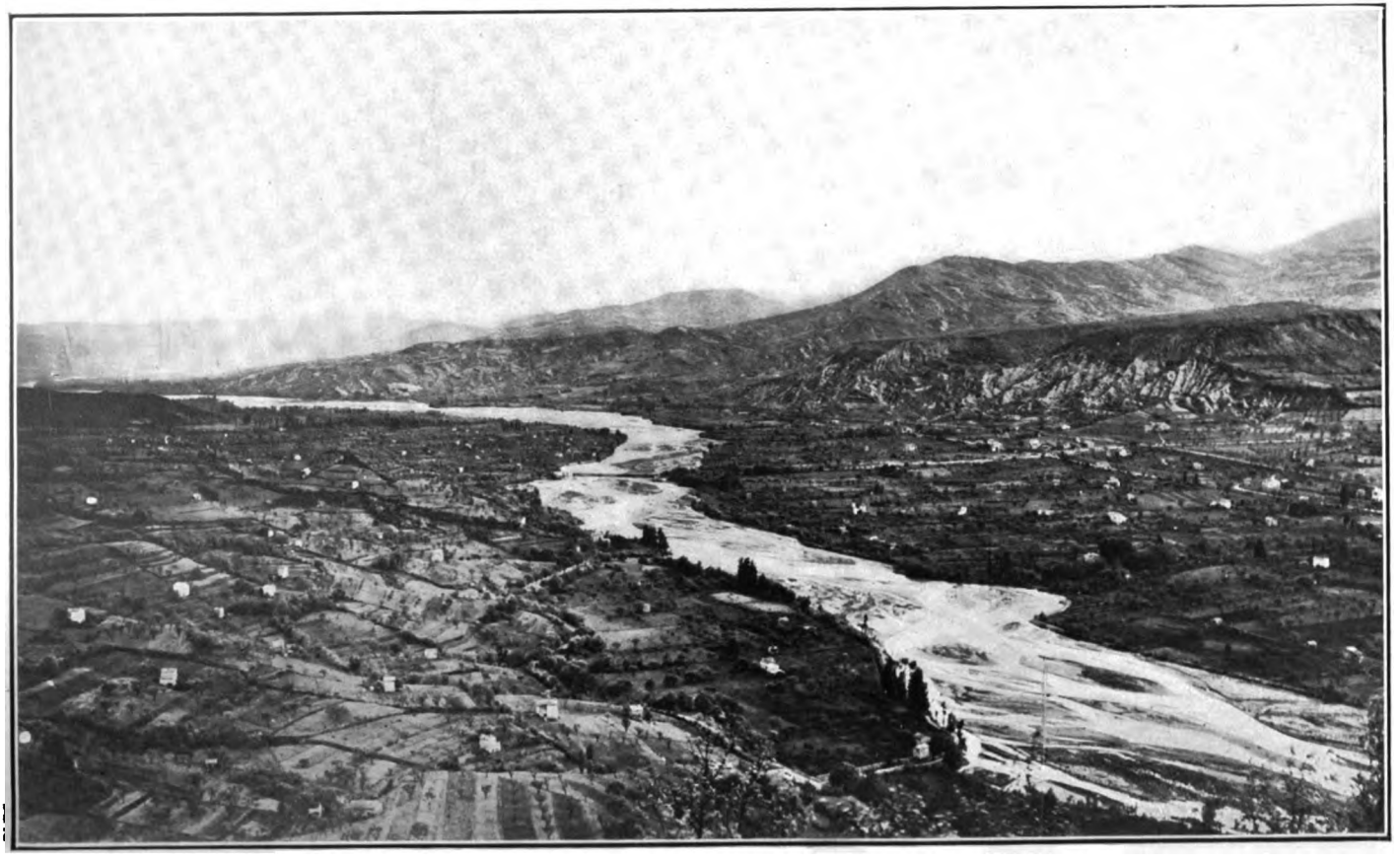

NO. 14.—FRANCE. SCENE IN THE BASSE-ALPES, IN THE VALLEY OF THE DURANCE NEAR DIGNE.

Showing the deforested and eroded mountain slopes and the overloaded river, which is unable to remove the sands that fill its channel. (Photo by B. W.)

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America differs from the Mississippi Valley. To this fact is due in large part the difference of opinion which exists among European writers as to the influence of forests on precipitation, springs, and run-off. Those who have observed in northern Europe the effects of deforestation of flat lands under humid climates minimize or deny entirely any influence exerted by forests; while those whose experience is with warmer, more arid, and consequently more critical conditions in mountainous southern Europe are convinced that forests exert an important beneficial influence upon rainfall, ground storage, and surface waters. To cite the latest conclusions we may quote from Cipolletti.[a]

It is generally admitted that regions covered with forests have a lower temperature than the open country, and the reason assigned for this is the evaporation from the surface of the leaves moistened by the rain, the area of which surface is estimated by Mr. Schleiden at fifty times that of the ground. Another cause is the constant evaporation during the vegetation season by exhalation of the same leaves, which Mr. Lafosse estimates at 150 cubic meters per hectare and day; and, finally, the large quantity of heat lost through the fixation of carbon, which the same Mr. Lafosse, upon the data furnished by Messrs. Lecart and Parisel, estimates, per hectare and day, at so many calories as will melt a block of ice 316 cubic meters. On the other hand, these same quantities of water which the forests continually emit into the atmosphere must help to increase the degree of humidity of the parts which immediately surround them. Thus, while on the one hand the temperature is lowered, the humidity is, on the other hand, increased; and hence it appears to be quite a logical and natural conclusion that within the forests the point of saturation of the air must be reached more quickly and more frequently than in the open, and consequently rain will also fall more frequently and in greater quantities.

This theoretical conclusion is borne out by abundant facts and experimental data.

Mr. Riedel quotes the island of St. Helena and Lower Egypt. On the former, owing to reforestations effected on a large scale, the rainfall has actually been doubled since the times of Napoleon I; and in Lower Egypt, where in the eighteenth century rain only fell on from ten to twelve days in the year, the number of rainy days nowadays reaches from 30 to 40, since some 20,000,000 of trees have been planted. On the other hand, on the shores of the Mediterranean, in Syria and Palestine, there are numerous regions which were formerly in a flourishing condition, but have become to-day arid and waste in consequence of the destruction of forests.

Mr. Ponti refers to the observations made at the Nancy school of forestry, which were confirmed in Russia by Professor Volsky, and by which it has been found that the rainfall in the interior of the forests was greater than outside of them. He adduces also the facts that in England, although it has not been possible to prove that the deforestation has caused here any reduction in the amount of rainfall or any appreciable change in the climate generally, it has been found nevertheless that the temperature is lower in forest-covered regions, the difference being as much as 3 degrees on the hottest days.

In regions where a considerable part of the precipitation is in the form of snow the forest catches it in the branches, protects that which falls to the ground from the sun, and retards its melting. These effects bear upon the proportions that evaporate or run off or sink into the ground and will come under those heads. It does not appear that forests influence the amount or distribution of snowfall.

Forests in relation to ground water.—Inasmuch as ground water and soil moisture are wholly derived from precipitation, any effect that forests may have in regulating rain extends to them. As compared with bare ground which receives all the rain and snow that fall,

[a] Permanent Intern. Ass. of Navigation Congresses. X Congress, Milan, 1905. Report by Cipolletti, C., on Deforestation, etc.

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the ground beneath trees gets only a part, as they catch some proportion in their foliage. The percentage caught varies from 20 to 40 per cent of the precipitation measured in adjoining fields, according to the kind of trees, the density of stand, and other factors. Thus, if the conditions for percolation are the same under the trees and in the open, the earth under the forest receives less than that under the bare surface. An approximation to this assumption is reached on level plains, provided the soil in the open be in an excellent state of tilth.

That proportion of the rain and snow which reaches the ground under the trees wets the mulch of mosses, leaves, and decaying wood, and such part as is not thus absorbed seeps into the ground below. Only a small part escapes as run-off, unless the slopes be very steep. The mulch of decaying vegetable matter is extremely absorbent and will hold as much as 50 per cent of its own volume, or two to three times its weight of water. From extended experiments in Germany with straw, leaves, and humus it appears that the moisture thus caught is evaporated to the air in dry seasons, and it would therefore be uneconomical from the point of view of ground-water storage to increase the surface litter beyond that required to prevent run-off. Under some conditions of forest maintenance it would probably be economical to keep the surface comparatively clean of litter and in an open state, such that the rain sifting gently through the foliage would be absorbed by the ground in a maximum degree.

The subsoil beneath the forest near the surface is moister than that beneath the adjoining fields. This is due chiefly to the covering of moist surface litter and to the relatively small evaporation at the ground surface. Deeper in the subsoil, at depths below a foot, the forest soil is often drier than that below the adjoining fields, for the tree roots take a large amount of water which is given off through the foliage. Thus, if we contrast the soil condition under the forest with that under the bare field we shall find the ground beneath the forest moister near the surface and drier below. The continuity of water films in the ground is a condition which promotes percolation, and the relatively moist surface layer thus aids the falling drops in reaching the deeper, drier layers when precipitation occurs. In the open, when the surface layer becomes measurably dried out and filled with air, a sudden rain may so occupy the pores of the immediate surface as to seal them against the escape of the underlying air, and the latter then prevents the percolation of water, and the impervious surface becomes one on which run-off is inevitable.

The total effect of trees in preventing some proportion of the rain from reaching the ground and in using some part of the moisture contained in the ground in their physiological processes is indicated by the depths to which they depress the level of ground water as compared with that in adjacent fields. Observations on this point have been made in Russia, France, and Germany, and the results are in agreement for European conditions. They were made on level ground, and the conclusions do not apply where run-off from the surface is copious. It is shown that—[a]

(*a*) The water table lies deeper below the surface under a forest than outside of it, if account be taken of the relief;

[a] Henry E.: Les Forets de Plaine, Les Eaux et Forets, vol. 42, 1903, p. 161.

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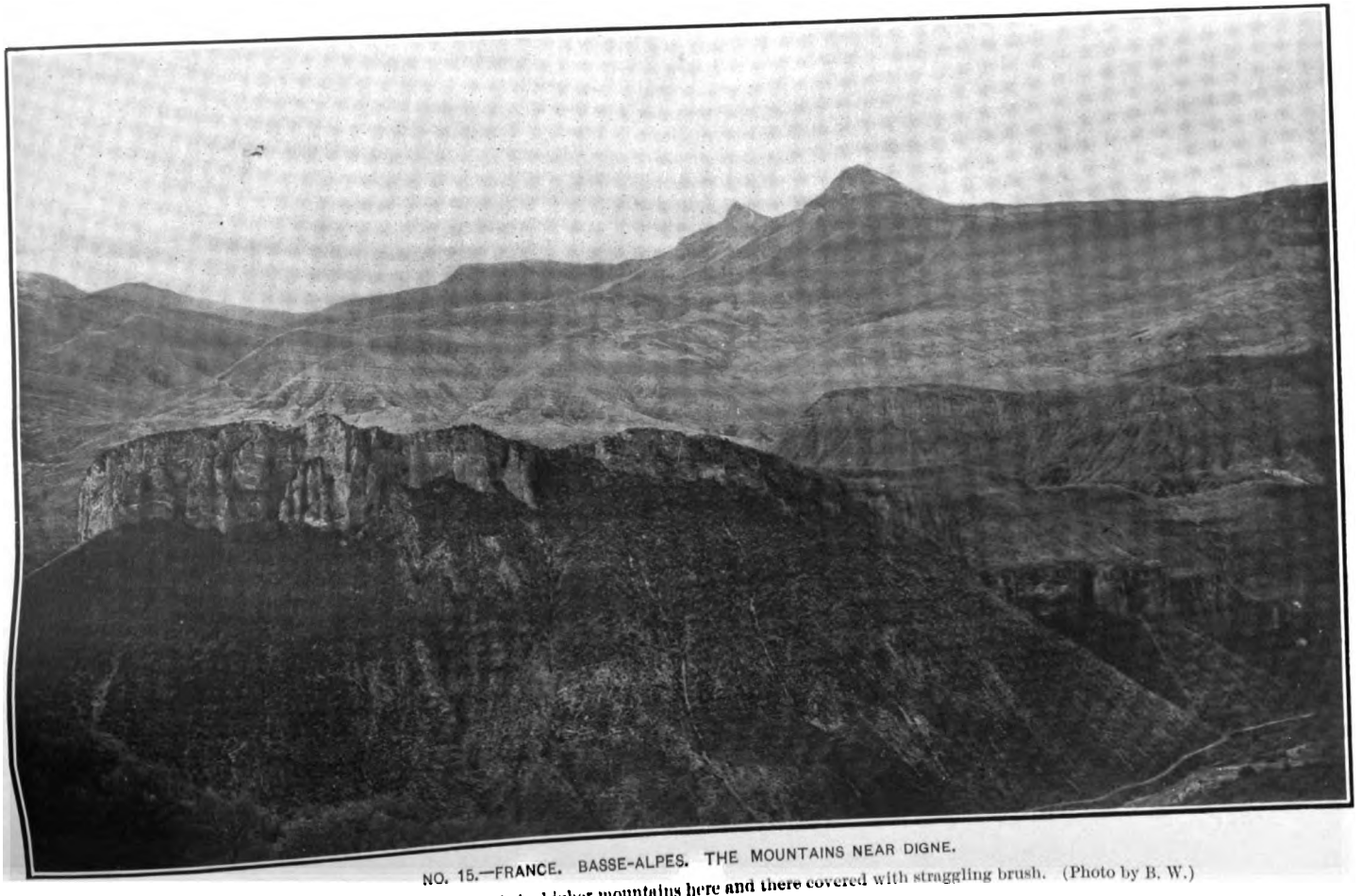

NO. 15.—FRANCE. BASSE-ALPES. THE MOUNTAINS NEAR DIGNE.

Showing the widely deforested slopes of the higher mountains here and there covered with straggling brush. (Photo by B. W.)

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(*b*) The depression of the water table is more pronounced under old forests than under young plantations;

(*c*) The depression is more pronounced in dry climates than where there is much rain.

The amount by which the water table may be depressed varies from a fraction of a meter to as much as 3 meters. It is observed in the level steppes of southern Russia, where the rainfall is moderate, that springs are found outside of the forests rather than in them. In citing these results, it is important to insist upon the distinction to be made between level and sloping surfaces. A comparison of the ground-water level beneath the forest with that beneath a flat field in which percolation is at a maximum gives an entirely different result from a similar comparison, in case the surface is so inclined as to permit run-off from the bare ground.

According to very careful and accurate observations made in Switzerland from 1903 to the present time and still in progress, it is found that the run-off from a wooded watershed is but 60 per cent of that from a cleared watershed, all other conditions being the same; and that the maximum high-water level of the stream from the former is 30 to 50 per cent lower than that of the stream from the latter.

The same observations establish the reciprocal fact that there is a larger and more continuous percolation of water into the ground and steadier flow of springs during drought from the wooded watershed than from the cleared watershed.[a]

Forests in relation to evaporation.—At the surface of the soil moisture passes into a state of vapor and is carried away by the air; this is evaporation. At the surface of a leaf moisture is given off by the living organism; this is transpiration. Evaporation is a physical phenomenon which increases with the dryness, temperature, and movement of the air; transpiration is a physiological phenomenon which depends upon the kind of plant and its response to the conditions to which it is exposed. Evaporation from the soil draws upon the moisture contained in the capillary spaces between the soil grains and extends down to the point where the soil is saturated—that is, to the water table in humid regions, or in arid regions to the point where the subsoil is so dry that the capillary films are no longer in contact. It continues until the available moisture in the soil is so reduced that the tension of the films about the soil grains becomes great enough to resist the tendency toward vaporization at the surface and evaporation then practically ceases, although diffusion into the air spaces of the soil continues even at some depth. Transpiration from the surface of the leaf responds in some measure to sunlight and shade, to humidity and dryness, and to temperature. Among these humidity is the most important. The rate of transpiration is, however, subject to physiological regulation, the mechanism of which is not understood. In certain experiments conducted by the desert laboratory it was found that in plants under examination the water loss due to transpiration was checked at temperatures above 79° F., whereas the checking action disappeared at lower temperatures.[b] Thus, some

[a] Engler: Der Einfluss des Waldes auf den Stand der Gewässer. Centralblatt für das gesammte Forstwesen, Jan., 1907, pp. 35–40

[b] MacDougal, D. T.: Botanical features of North American Deserts. Carnegie Institution, Publication 99, 1908, p. 86.

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plants possess a means of defense against excessive transpiration during hot weather and drought, whereas the inert soil must go on yielding moisture almost to the last atom.

There is a certain amount of evaporation from the leaf surface, but it is exceedingly slight. It differs from transpiration in that it takes place through the tissue itself, whereas transpiration occurs through the stomata. A grape which has no stomata gives a good illustration of the very small amount of evaporation from such surfaces.

Underneath the trees in the forest the conditions are much less favorable to evaporation from the soil than in a bare field near by, the humidity being higher and the temperature very much lower. Above the trees also the air is cooler and more humid than it is at the same altitude above bare ground. This last statement requires some explanation. Sunlight passing through the air raises its temperature somewhat, but a more important influence is that of the currents of air set up by contact with the surface upon which the sunlight falls. We all know the heat which rises from bare ground, and how comparatively cool is the sward. Similarly the surface of the ground is hotter than the surface of the foliage of a forest. The effect of radiation from these two contrasting surfaces is shown by the experience of French aeronauts to extend to a considerable height. According to E. Henry:[a]

> The cooling effect observed by æronauts in passing over forests of a certain extent is indicated by a marked descent of the balloon. It is a well-established fact that this effect was experienced by a number of military balloonists above the forest of Orleans, the balloon being at an altitude of about a thousand meters. It appears to be demonstrated by the balloon ascensions made up to the date of the statement that the influence of forests of similar extent (34,000 hectares, or about 20 square miles) is observable up to an altitude of 1,500 meters.

To sum up the preceding considerations: The effect of these complex relations has been made the object of investigation, particularly in Germany, through the study of the amount of moisture remaining in the soil under the various kinds of trees, and in the adjacent open. Some reference to these results has already been made; but the general conclusion is that the effects of transpiration from luxuriant foliage are very materially greater than those of evaporation from the bare level surface.

The most striking illustration of this factor is the effect of eucalyptus trees, which, planted in the Pontine marshes near Rome in 1870 (in the vicinity of the Convent of St. Paul of the Three Fountains), have lowered the level of the ground water several decimeters. In this case the transpiration from the water-loving eucalyptus is more vigorous than was the evaporation from the water and vegetation of the swamps.

The relation of the forest to run-off on level lands is not an important factor. As we have already seen, it is possible to keep level fields in such a condition of tilth that the amount of run-off from them is no greater than that from the forest. On slopes the case is different.

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[a] Henry, E.: Sur le rôle de la forêt dans la circulation de l'eau à la surface des continents. Comptes rendus du Congrès des sociétés savantes en 1901.

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The effect of the forest is, first, to diminish the violence with which the rain strikes the ground and compacts it, for the drops are checked by the foliage. They fall from branch to branch and reach the ground with greatly diminished momentum and in a finer state. That portion which drops from the leaves comes in larger masses, but still gently. Beneath the forest the rain finds a moist soil whose capillary water is capable of vigorous downward circulation. The soil is also opened by the forest roots, and being protected from the compacting and cementing influences of a free exposure is decidedly porous. All these conditions militate against run-off and promote absorption. In consequence the run-off from forest areas gathers slowly as compared with bare slopes, and the ratio becomes increasingly favorable in regard to forests as slopes become steeper. This fact enters into the consideration of the value of forests in mountain regions as compared with those on plains. Ebermayer,[a] from whose paper many of the data used in this report have been taken, says:

In view of the exact investigations which have been cited above, and which extend through thirty years, it is no longer possible to maintain the assumption so generally made, that forests increase the amount of ground water and constitute a storage reservoir for the supply of springs, *at least not so far as plains are concerned.* The draining effect of the forest is, on the contrary, so great that a much greater supply of water gathers in the depths beneath a treeless plain than beneath dense woods, provided that the underground conditions be the same in both cases. It follows that under these conditions the discharge of springs is not increased, but lessened, by woods. *Decided emphasis must, however, be laid upon the fact that these conclusions hold primarily only for the plains, and are not to be extended inconsiderately to uplands and mountains.* Although the influence of the woods upon soil, moisture, percolation, and ground water under like conditions must be the same in mountains as it is in lowlands, and only moderate differences are likely to appear, nevertheless the forest on the mountain differs very decidedly from that on the plain in regard to water control, inasmuch as in mountain regions, in consequence of the surface run-off of rain and snow water from the slopes, a factor is introduced through which wooded mountain slopes receive a much larger amount of water than bare, unwooded watersheds.

Forests in relation to erosion.—The emphasis which Ebermayer lays upon the loss through run-off from bare slopes is in no sense exaggerated. The detrimental character of this loss in relation to storage of water for all the activities of civilized communities, including navigation, can not be exaggerated. Its effects have already been described in speaking of flood run-off, but we may here recur to the injury which it does, particularly with reference to the erosion of soil. If it were conceivable that we could adjust our activities to the loss of one-half of the available water through flood run-off it would still be inconceivable that we could permit the accompanying loss of the soil. Without soil the earth becomes a desert. Without soil man must cease to exist.

This consideration is of prime importance everywhere, but it assumes overshadowing importance beyond any other in mountain regions of large rainfall. The Appalachian Mountains constitute such an area of great extent and of very marked character, and they occupy a very critical position in the center of the richest half of our

[a] Ebermayer, Ernst: Einfluss der Wälder auf die Bodenfeuchtigkeit, auf das Sickerwasser, auf das Grundwasser, und auf die Ergiebigkeit der Quellen. 1900, p. 38.

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country. Concerning the effect of uncontrolled run-off from this region we have, unfortunately, abundant evidence, the emphatic testimony of ruined and abandoned lands.

Summing up the observations of the thoroughly qualified and unbiased observer, L. C. Glenn, we are able to show what relation the destruction of the forest bears to run-off in the watersheds of the southern Appalachians.

Forty-six creeks and small rivers, whose watersheds may be described as timbered rather than cleared, are known, according to observation and local repute, in times of flood to rise gradually, to continue high for several days, and to subside slowly. They carry but little sediment, and they maintain a good volume of water during dry seasons.

Thirty-eight creeks and small rivers in the same watersheds, whose slopes may be described as cleared rather than timbered, are known, according to observation and local repute, in times of flood to rise rapidly to extreme flood height, to carry excessive quantities of mud, sand, and gravel, and to fall quickly. In dry seasons they are very low, and the range from lowest to highest stages has increased and inflicted much damage in very recent years.

Two other classes of conditions may be recognized in Professor Glenn's descriptions: The one, of valleys still timbered, but which are being damaged by beginning of logging and particularly by erosion of logging chutes; the other, of watersheds that are largely cleared but grassed, and which the grass protects from erosion, though not in the same degree from rapid run-off.

Such evidence as this, collected by a qualified and impartial observer with reference to individual watersheds, establishes for the region in question, comprising the mountains of North Carolina, Tennessee, and Georgia, the fact that forests exert a beneficial influence on stream flow by storing the waters from rain, preventing their rapid rush to the streams, and paying them out gradually afterwards, thus acting as true reservoirs in equalizing the run-off.

These detailed observations sustain the general facts which every mountaineer knows: That streams which flow from a forested area rise slowly, carry little sediment, and fall slowly in times of flood, and throughout the year are relatively far more uniform in their flow, whereas streams which flow from deforested regions rise quickly, carry heavy bodies of sediment, and sink early in the season of drought to minimum low-water stages.

On the basis of superficial observation it is sometimes said that deforestation as it is now proceeding in the Appalachian Mountains does not seriously affect the streams, because the forest which the lumberman cuts is soon replaced by an aftergrowth. It is true that the full effect of deforestation follows immediately upon lumbering only in extreme cases, but wherever the forest and the superficial forest soil are removed a beginning has been made in the process of erosion which will ultimately remove all the soil. The aftergrowth that follows the severe cutting and burning under modern lumber conditions is a weakened growth. It never covers the surface as the virgin forest did; the surface is always traversed by freshly cut gullies, and the level of channel grades is sunk below it from a few inches to 10 feet or more. The advantage thus given to the eroding

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power of thousands of rills is not overcome by any natural process. Man alone can so direct and localize a defense as to make it effective, and he does it only at great cost. It is true that under favorable conditions the soil will maintain itself till the trees of the aftergrowth become merchantable timber, and that the processes of cutting, burning, and partial erosion might under the most favorable circumstances be continued till several crops had been cut from the surface and a half a century or more had passed, but the result would be deferred merely. That result is to be seen in the bare mountains that stretch from Spain to Asia Minor and in those of northern China.

The forests have long protected the Appalachian Mountains; they were growing throughout the eastern United States when a great plain stretched unbroken from the Atlantic to the Mississippi, and they have continued their growth, though changing in species and in distribution, while the earth's surface has been raised to the heights from which the mountains are being carved. During the whole process the forests have conserved and protected the mountain slopes from washing.

Let us pause to consider the slow changes of the ages that preceded the advent of man, the destroyer—or possibly the protector.

On a vast plain covering the area of the eastern United States and Canada there grew a luxuriant forest. The plain was almost continuous. A few broad, low hills rose from it where now are North Carolina and eastern Tennessee. In the forest grew the tulip tree and the magnolia, along with many species that are now gone, but the modern oaks were not yet developed.

Within the earth titanic forces gathered gradually till their power sufficed to raise the surface slowly and to elevate the plain. Rising in a zone that reaches from Canada to Alabama the elevated plain became a plateau from which many rivers flowed to the Atlantic and Pacific. As the slopes steepened, the waters, falling swiftly, cut their channels deeply and made canyons, which widened to valleys. Genial climates favored vegetation, which during the long, slow process of mountain growth and valley carving never was removed extensively. Woods prevailed and held the soil, always adjusting their growth to the very gradual changes of the valley slopes. If perchance a steep was bared by a sudden landslide, it was in time washed clean to the hard rock and became a cliff, or caved and extended till vegetation could take a foothold again. Thus the mountains of to-day were slowly carved from the upraised mass, and ever through the ages the forest trees grew and flourished and died, generation after generation, in the soil their roots held fast and enriched and deepened. It was their destiny to outlive the mountains, whose inert mass must yield eventually to the unceasing attacks of erosion and be worn down again to a gently sloping plain, over which the forest should stretch its living covering. But man has come, he holds the forests' destiny in his hands, and his own is intimately linked with theirs.

CONCLUSION.

The effects of rainfall in critical regions are not beyond man's control.

The methods of control are incident to agriculture, grazing, and forestry, and their application pays in larger crops, better feed, and

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bigger cut per acre, as well as in national welfare both present and future.

The circulation of water in the streams, like the circulation of blood in the veins, carries the effects of negligence or care through the whole body of the commonwealth.

Every farmer, herdsman, lumberman, and landowner is morally responsible to his community for his influence on waters and their effects, and should be held to that responsibility by his conscience, by public opinion, and by law.

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METHODS WHICH SHOULD BE ADOPTED BY PRIVATE OWNERS TO INSURE THE PERPETUATION OF OUR TIMBER SUPPLY.

By C. S. CHAPMAN,
United States Forest Service.

IN GENERAL; METHODS TO BE ADOPTED.

The best available statistics show that in the United States the annual cut of timber is from three to four times as great as the annual growth. This fact is conducive to conjecture as to the timber supply of the future, and as to the measures to be taken to prevent a future shortage with its inevitable depressing effects on the business and development of the whole country.

Steps looking to the perpetuation of our timber supply, so far as private owners are concerned, must be along two broad lines:

1. Aid by the Federal Government and by States to private owners by legislation and assistance, making it possible for private owners to successfully and profitably practice forestry.

2. The actual practice of forestry by corporations and individuals, which alone can increase the productiveness of forest lands and insure a future supply.

These two subjects are so closely connected that one can not be treated without, to some extent, touching on the other.

IMPORTANCE TO COUNTRY OF PRIVATE HOLDINGS.

The most liberal estimate of the wooded area of the United States, that of the Geological Survey, places it at 700,000,000 acres, while others have placed it as low as 500,000,000 acres.

Of the amount estimated by the United States Geological Survey, there were on July 1, 1908, 156,082,756 acres in national forests, and 2,582,711 acres in state holdings. This leaves the area of woodland held by private owners, or which will probably pass into their hands, 541,334,533 acres, or over three times as great an area as is held by the Government and States combined. If this area represents its proportion of the timber cut of the United States, which is a fair assumption, three-fourths of the timber supply is on private lands.

It is evident, therefore, that no matter what measures are taken by the Federal Government and by the States to properly manage their forest lands, unless the great area held by individuals is properly cared for the future timber supply is far from being assured.

Since the annual timber cut of the United States is from three to four times as great as the annual growth, the situation will not be

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satisfactory unless, under forest management, timber can be made to grow from three to four times as rapidly as at present. A similar situation has been successfully met in other countries and undoubtedly can be in the United States.

There are at the present time, both in the hands of private individuals and of the Government and States, large tracts of land which should and will be planted. Lack of authoritative data makes it impossible to say how much land there is in the United States which does not now but would support forest growth and yield better returns from a forest crop than from any other. Combining the treeless areas of the West, the cut and burned-over lands of both East and West which are not restocking, and the land put to some kind of agricultural use but best adapted to the growth of timber, the area is emphatically worthy of consideration in connection with a national timber supply. It is, of course, true that much land now in forests could serve its highest usefulness as farm land and that, with the increase of population and with better and more intensive methods of farming, land not now considered of any value for agriculture will be used for this purpose.

It is certain, however, that this enlargement of agricultural areas to include land now forested can not permanently exceed the amount of treeless areas that should be planted, so that eventually the forest-covered area of the United States should be at least no smaller than at present. Even this means intensive forest management if the United States is to furnish its own timber supply. Economy in use and the extension of preservative treatment of timber will also serve to aid in the perpetuation of the country's supply of wood.

AID TO OWNERS OF PRIVATE TIMBER LANDS.

Many private timber holders are now practicing forest management of some nature. Exactly how many, it is impossible to say. (See Tables I and II.) A mention of the work done by the Forest Service to assist private holders will give a general idea of the interest taken. Up to June 30, 1908, at the request of owners of woodland, 568 examinations of tracts were made by trained foresters of the Forest Service. The number of cases where assistance was asked and could not be given was large. The area affected by the examinations was 10,280,783 acres, in 41 States and Territories.

In a number of cases detailed working plans were made for the conservative management of the timber tracts. Much of the cost of the work was at first borne by the Forest Service, for the purpose of stimulating interest in forest management and to secure necessary data for the Government on the growth of trees, their silvicultural characteristics, and best means of management. At present, however, the owners of woodland must bear the greater part of the expense themselves, except in rare instances where the preparation of a plan would be of unusual educational value, or when a plan has never been made by the Service in the region.

In April, 1907, the Forest Service sent out a circular letter to 100 owners of small timber tracts and to 402 owners of wood lots, requesting them to make a statement of the work done on their lands as a result of recommendations of the foresters who examined their tracts. To these letters 152 replies were received, showing that 102

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were carrying out the recommendations of the Service. Twenty-one reported some work in progress and 29 had done nothing. If this may be taken as a fair sample, more than 450 of those who have received aid from the Federal Government are now practicing forestry, at least to a limited extent.

Up to June 30, 1908, 452 persons received actual help on the ground in forest planting affecting nearly 64,000 acres. In addition a large number of people received aid through correspondence. About 32 per cent of the plans made were carried out either wholly or in part.

In addition to the aid given by the Forest Service a number of States have given, through their state foresters, valuable assistance at small cost. Notable among the States well equipped to do this work are Connecticut, Massachusetts, and California.

Also, the publications of both federal and state governments have aided private owners very greatly by giving valuable information on the handling of natural forests and on forest planting.

Laws have been passed in nearly all States to prevent forest fires and other sources of forest destruction. Twenty-six States have boards or commissions whose whole or partial duty is to look after forest matters of the State, and nine of these States have state foresters. Twelve States have tax-exemption laws in some form, and several others offer rebates and bounties. There are still some States which have shown little interest and have not considered forest preservation a question of sufficient importance to warrant the enactment of laws to help their citizens.

PRIVATE FORESTERS.

As yet there are not many foresters in private employ. A few lumber companies are now employing them, and a few firms of consulting foresters are at work. The best figures attainable, however, do not show over 70 private foresters actually doing professional work or teaching.

While the interests of both Government and State make it desirable that necessary aid be given those who apply, advice on the ground and plans for caring for timber land should more and more be done by the private forester. As large companies become really interested in forest work and take it up as a business proposition, they will secure the services of trained men. As soon as the practice of forestry becomes accepted as good business policy there should be an end to the great duties of State and Federal Governments as disseminators of knowledge and stimulators of forest preservation through aid other than by legislation, and then the field can be left very largely to private foresters.

THE PRACTICE OF FORESTRY BY OWNERS OF TIMBER LANDS.

Owners of timber land may be broadly classed as—

(*a*) Those who purchase for speculation and hold for a rise in stumpage prices;

(*b*) Those who hold for game or pleasure preserve and not for profit;

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(*c*) Those who either hold to supply their mill, to furnish logs for market, or to furnish fuel, posts, and other necessary timber either for home use or for sale.

Those of the first class obviously do not cut their timber, and aside from necessary protection from trespass and fire which might result in financial loss they are not interested in any form of forest management.

Those of the second class will and generally do practice forestry if it will foster any of the purposes for which the forest is held; and as forest management may mean money return without lessening the beauty or value of the forest, the owners are generally favorable to forest management. A forest of this class is that owned by the Blue Mountain and Forest Park Association in Sullivan County, N. H. This tract, which contains about 15,090 acres of woodland, is held by the owners as a permanent game preserve. Under forest management it is possible to so care for the tract that its usefulness as a game refuge is not interfered with, and at the same time a considerable revenue from the sale of timber is secured. The tract has been managed by a forester since 1904.

The third class of owners hold their land for profit, direct or indirect. This is by far the largest class and the one on which the future timber supply of the country must rest. Forest management, unless it shows good financial returns—better returns, in the long run, than under present methods—has no attraction for this class of owner. This is only natural. Many of the large holdings are owned and worked by stock companies, to secure profit on their investments. If forest management can not show a profit to this class of owners it will not be practiced. If it can show profit and this class of owners can be led to see its advantage, they will adopt it. It is therefore very important that every possible measure be taken by the Government, by the States, and by private owners to determine the proper management of timber lands in different sections and ascertain the profits and benefits to be derived.

One great drawback to forest management by private owners has been the ordinary attitude toward a timber tract. It has been formerly and is still often looked upon as a source of supply which when cut over is gone for all time; and the possibility of continuous crops is not thought of. In the case of a manufacturing plant the attitude is quite different. The company putting up a large and expensive saw or paper mill that costs from fifty thousand to several million dollars plans to have this plant run for a sufficient number of years to warrant the investment. If a supply of timber to last through this period is not already owned, the possibility of purchasing material is carefully calculated, rather than the possibility of growing a second crop. In the past it has been profitable to cut over a tract without regard to future crops, and then with the profits to purchase another tract to be treated in the same way. This practice has had extremely disastrous results, for it has left cut-over areas in a condition which it will take years to correct, and made it possible to so increase the output of lumber when prices are good that overproduction and a resultant market depression ensues.

One great argument against forest management is that because of fluctuating prices safe calculations of values can not be made a long

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time in advance. In older countries prices of forest products are more stable and the crops can be harvested each year in accordance with an annual or periodic production of wood. With varying prices there is a decided tendency to over-cut whenever prices are high and hold when they are low. This, of course, interferes with systematic forest management. However, stumpage is becoming more valuable, timber land more and more is getting into the hands of large companies who will hold for a second crop, and as it becomes more difficult to buy another tract from the profits of the one cut over, cutting with a view to a second, a third, and succeeding crops on the same land must result.

HOW SHALL PRIVATE TIMBER TRACTS BE MANAGED?

It is extremely difficult to say how private timber tracts should be managed. In a country that varies so greatly in climate, topography, variety of species, and market facilities, what is good management for one tract becomes bad for another; and the problems become so local in application that it is conceded by foresters that each tract must have its management prescribed after a careful examination on the ground. The application of general rules for the management of tracts in various parts of the country is impossible, and it is equally impossible to give information in a single report. Moreover, any information given would be of necessity too general to be of much real value. The Forest Service has issued publications on the management of woodlands in various sections, and some of these are given as references to any timber-land owner within a region specifically covered. Modifications will, of course, have to be made to suit individual conditions. Many other works on forestry have been published, and anyone desiring information on forest management can easily secure such information from some of the publications of the Forest Service.

List of some of the publications of the Forest Service containing valuable information regarding forest management.

GENERAL.

Bulletins.—No. 5. What is Forestry? No. 11. Some Foreign Trees for the Southern States. No. 15. Forest Growth and Sheep Grazing in the Cascade Mountains of Oregon. No. 16. Forestry Conditions and Interests of Wisconsin. No. 24. A Primer of Forestry (Parts 1 and 2). No. 42. The Wood Lot. No. 47. The Forest Resources of Texas. No. 49. The Timber of the Edwards Plateau, Texas. No. 55. Forest conditions of Northern New Hampshire. No. 66. Forest Belts of Western Kansas and Nebraska.

Circulars.—No. 10, No. 11, No. 13, No. 14, No. 21, No. 35, No. 79, No. 97, No. 140, No. 149.

TREE STUDIES.

Bulletins.—No. 12. The Timber Pines of the Southern United States. No. 22. The White Pine. No. 33. The Western Hemlock. No. 38. The Redwood. No. 53. Chestnut in Southern Maryland. No. 58. The Red Gum. No. 63. The Natural Replacement of White Pine in Old Fields in New England. No. 64. Loblolly Pine in Eastern Texas, with Special Reference to the Production of Cross Ties. No. 69. Sugar Pine and Western Yellow Pine, California.

Circulars—No. 40, No. 118.

WORKING PLANS.

Bulletins.—No. 26. Practical Forestry in the Adirondacks. No. 30. A Working Plan for Forest Lands near Pine Bluff, Ark. No. 39. Conservative Lumbering

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at Sewanee, Tenn. No. 43. A Working Plan for Forest Lands in Hampton and Beaufort Counties, S. C. No. 56. A Working Plan for Forest Lands in Berkeley County, S. C. No. 60. Report on an Examination of a Forest Tract in Western North Carolina. No. 68. A Working Plan for Forest Lands in Central Alabama.
Circular.—No. 131.

PLANTING.

No. 18. Experimental Tree Planting in the Plains. No. 27. Practical Tree Planting in Operation. No. 29. The Forest Nursery. No. 37. The Hardy Catalpa. No. 45. Tree Planting of White Pine in New England. No. 52. Forest Planting in Western Kansas. No. 65. Advance of Forest Planters in Oklahoma and Adjacent Regions.
Circulars.—No. 6, No. 54, No. 22, No. 55, No. 109, No. 37, No. 61, No. 45, No. 99, No. 145, No. 41, No. 100.

There are certain fundamental rules which must, of course, be followed in the practice of forestry everywhere. Timber must not be cut faster than it is produced, if an equal annual or periodic yield is desired. If reproduction is to be secured through natural means, young growth must be cared for. A tract must be at all times guarded against destruction by fire and insects. Waste in logging must be avoided. Unless restocking is to be by planting, the basis for a second crop must be left on the ground either as seed trees or young growth. Often the mere prevention of fire will in itself result in a good growth of young timber.

A number of large timber-land owners are now practicing forestry. Some of these are C. F. Craig Timber Company, West Virginia; Delaware and Hudson Lumber Company, New York; Cleveland Cliffs Iron Company, Michigan; and Pennsylvania Railroad Company.

All of these companies employ foresters. In addition there are others who, though they do not employ foresters, are doing something to protect their land and grow a second crop. The Santa Clara Lumber Company, of New York, while not engaged in systematic forest management, is leaving a considerable amount of timber standing, and is planting skid roads and other open places as soon as an area is logged over.

In the August number of the Southern Industrial and Lumber Review there is a very interesting article on the practice of forestry by lumbermen in the pine belt of Texas. The company that publishes this journal sent out a number of letters to prominent timber holders and lumber manufacturers in Texas and asked if they had any plans for conserving their timber or reforesting their cut-over land; if any attempts toward these ends had been made, and, if so, with what success. The Journal states:

> In the first place, practically all of the lumbermen declared themselves unconditionally in favor of any fair plan that could work for the insuring of future forests could such a plan be discovered. None of them advanced a feasible plan for securing such an end, and it is safe to say that no human being in all this public discussion of the matter has yet advanced a practical plan whereby the objects desired could be attained.

Three of the firms written to were taking measures to conserve their timber, and others wrote that they intended to do so in the near future.

The Southern Industrial and Lumber Review draws the conclusion from the answers received that one of the cogent reasons why forestry can not be practiced is that taxes are excessive. Its publishers also believe that if timber lands were exempted from taxation until

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the crop is merchantable it would be a great stimulus to the practice of forestry.

It is interesting to note that the trade journal quoted considers that no feasible plan for the management of forest lands in the Texas pine belt has been set forth. More than most regions this section has been studied by foresters, and their conclusions and plans for managing various tracts are of record. The trouble is that while many timber-land owners are now holding their land for future crops (see Tables I and II) few are doing more than this. An expenditure whose returns will show only after a long period is not considered seriously, and any plan for forest management entails a certain amount of expense. Timber-land owners, for the most part, demand a system of management which brings good results without extra expense to the business or any inconvenience in logging. Such a system is possible only in very rare instances.

Table I shows the results of inquiries to 3,629 lumber and coal companies for information about fire protection and the policy toward cut-over holdings. To these inquiries 1,331 replies were received, and of this number only 639 contained information complete enough to be tabulated.

This tabulation, which covers 24 Eastern States, shows that of a total area of 3,512,846 acres, 1,764,609, or practically half, is held for future crops, and if not now receiving some protection and care for the future, presumably will, eventually. It shows, too, that not all of the land held for a second crop is protected from fire.

It is also of interest to note that, while not quite 50 per cent of the land is held for a second crop, exactly half of the owners are holding their land for this purpose.

TABLE I.—*Forest ownership and protection.*

State.	Number firms reporting.	Amount represented.	Timber.	Held for future crop.	Protected from fire.	Number firms reporting acreage only.	Number firms holding for future crop.	Number firms protecting land
		Acres.	*Feet.*	*Acres.*	*Acres.*			
Alabama	23	309,104	567,314,000	256,466	17,830	11	11	3
Connecticut	1	950	2,250,000	950	.....	.....	1	.....
Florida	1	13,645	40,000,000	13,645	.....	.....	1	.....
Georgia	4	32,462	100,500,000	11,462	3,000	2	2	1
Illinois	21	5,509	7,658,000	2,302	.....	16	3	1
Indiana	14	3,367	5,000,000	.....	.....	9	.....	.....
Kentucky	50	210,768	526,687,000	78,102	14,250	21	22	7
Maine	40	350,772	910,385,000	339,888	218,696	5	32	10
Maryland	14	26,753	33,840,000	3,061	.....	.....	7	.....
Massachusetts	4	1,430	5,300,000	1,100	.....	.....	2	.....
Michigan	1	1,280	100,000	.....	.....	.....	.....	.....
Minnesota	1	1,600	400,000	.....	.....	.....	.....	.....
Mississippi	1	480	600,000	.....	.....	.....	.....	.....
New Hampshire	46	122,051	197,347,000	44,243	.....	2	28	.....
New Jersey	1	86,700	.....	86,700	.....	1	1	.....
New York	17	35,617	131,095,000	27,382	7,250	2	12	2
North Carolina	29	515,517	1,406,575,000	242,265	482,400	4	17	5
Ohio	41	40,339	14,105,000	36,971	25,035	27	16	6
Pennsylvania	126	201,777	221,847,000	114,478	80,868	59	64	30
South Carolina	3	5,450	53,300,000	5,050	.....	.....	.....	.....
Tennessee	44	588,150	1,403,200,000	219,789	272,528	12	23	5
Vermont	33	63,425	351,850,000	44,964	7,031	2	19	4
Virginia	27	180,565	566,971,000	113,045	2,800	11	8	2
West Virginia	97	785,135	1,790,261,000	122,746	65,454	36	50	13
Total	639	3,582,846	8,336,585,000	1,764,609	1,197,142	220	319	89

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TABLE II.—*Tabulated results, by States, of answers to 596 circulars of inquiries received from owners of timber tracts in the United States.*

State.	Number firms reporting.	Amount represented.	Protected from fire.	Number firms stating some form of forest management considered practicable.	Cut-over land held for future crop.
		Acres.	*Acres.*		*Acres.*
Alabama	7	277,000	227,000	.....	112,500
Arkansas	21	871,185	.....	5	70,000
California	13	216,099	156,000	1	117,000
Connecticut	16	27,250	16,500	6	22,400
Florida	13	787,400	.....	5	25,000
Georgia	11	158,702	115,902	7	4,800
Idaho	10	81,500	69,980	2	.....
Indiana	3	23,218	23,218	2	173
Kentucky	11	92,460	.....	4	72,810
Louisiana	35	1,349,136	488,000	12	440,000
Maine	12	126,300	90,000	6	126,300
Maryland	5	2,900	.....	.....	200
Massachusetts	37	2,036,865	10,115	17	18,590
Michigan	19	470,273	54,080	5	127,000
Minnesota	8	161,940	60,640	.....	2,140
Mississippi	22	659,100	47,000	1	31,000
Missouri	9	264,197	.....	1	612
Montana	14	68,620	36,460	3	.....
New Hampshire	9	163,200	102,200	3	142,200
New Jersey	3	3,308	3,000	1	308
New York	36	356,744	158,140	15	215,302
North Carolina	18	619,418	287,000	7	455,000
Ohio	1	.....	.....	.....	.....
Oklahoma	2	40,000	.....	1	.....
Oregon	46	357,380	309,870	.....	174,820
Pennsylvania	12	523,467	465,167	3	112,300
Rhode Island	3	4,030	.....	.....	2,050
South Carolina	12	183,064	2,000	1	15,000
Tennessee	11	175,740	91,500	2	.....
Texas	20	835,100	191,000	1	282,000
Vermont	9	66,300	37,300	2	66,300
Virginia	12	98,000	31,000	2	50,000
Washington	71	492,413	390,650	1	261,580
West Virginia	21	427,783	273,183	2	71,000
Wisconsin	44	1,124,912	239,682	3	109,700
Total	596	13,151,104	3,976,587	121	3,128,085

Table II shows the results from 2,089 schedules of inquiry send to members of lumber associations. Many of these had sold their land or were not actually operating in the woods, so only 596 satisfactory replies were received. This table, unlike the first, is compiled from replies from both Eastern and Western States. In all, 35 States are represented, and the interest shown in all sections was particularly good. Of more than 13,000,000 acres represented, nearly one-fourth was being held for a second crop, and a slightly greater amount was being protected from fire.

One of the questions asked in the schedule was:

What method of conservative forest management do you consider practicable in your section from a business standpoint?

A number of interesting replies were received.

The Rietbrick Land and Lumber Company, of Wisconsin:

As stated, no timber 10 inches and under in diameter is cut. By taking out older trees it gives a chance to younger trees for better growth. We expect to harvest these logs in, say, possibly fifteen to twenty years. We are giving consideration to young and thrifty timber on cut-over lands with a view of future crops. We have done this for several years, before which time it was not considered.

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The Eel River Valley Lumber Company, of San Francisco, Cal.:

Replanting redwood lands has been initiated to a small extent. Eucalyptus is being put out to a very limited amount. We planted last spring about 500 trees of the blue variety as an experiment. These trees were planted when about 1½ to 3 feet high on old logged-off land on a steep hill, where they were exposed to all the heat of summer and to the rain and storms of winter. No special attention has been paid to them, as it is desired to see what they will do on such land without special care. There is no water in the surface where they were set out. They have shown a strong, vigorous growth during the summer, and about 75 per cent have lived.

The Desert Lumber and Coal Company, of Arkansas:

Trees should be cut up to 12 or 14 inches diameter, younger trees left standing, and tops of trees cut should be burned up carefully; this would perpetuate our forest indefinitely.

The Conway Lumber Company, of Horry County, S. C.:

Cut no timber under 12 inches in diameter, 18 inches from the ground. Protect the small trees in cutting the big ones, and keep fire out of the forests.

The C. R. Cummings Export Company, Liberty and Harris counties, Tex.:

We cut only the larger timber and leave all small timber standing, cutting principally 12 inches and up in diameter.

The Shaw Land and Timber Company, of Tidewater, Va.:

None necessary except keeping out fire; do not cut the small timber; nature does it all in this flat country.

William Brown & Sons, of Worcester County, Mass.:

We cut off timber clean excepting a few seed pine, sowing to pine seed and reseeding from old pine trees.

Mr. Joseph H. Elliott, of Windham County, Conn.:

My method is to cut out everything ready for market and leave every small tree. The trees that are left grow faster, and in a few years another crop is ready for market.

Throughout the answers to the schedule, complaint is made of the high tax on forest crops, and legislation is suggested to lessen the burden of the owners in this respect. A number of the answers also suggest stringent government rules, accompanied by inspection, that will require private owners to leave a certain amount of timber on the ground when logging and require them to protect from fire. Several advanced the idea that the Government should buy cut-over land and hold it for a second crop, as the expense to the individual was too great.

In a large number of cases companies appear to be holding land for a second crop and, in addition, are endeavoring to keep out fire and to leave some timber on the ground. This is, of course, a very crude method of management, but in many instances it will no doubt result in the owner securing a good second crop and is an excellent indication that more intensive management will follow.

IS FOREST MANAGEMENT BY PRIVATE OWNERS PROFITABLE?

Whether or not forest management is financially successful depends almost entirely upon local conditions. It often happens that the value of a forest is indirect, but ordinarily, with fair market facili-

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ties, any tract can be so managed as to produce revenue. There is no question but that forest management pays on the farm wood lot, which is managed to supply the farm with fuel, posts, etc., and from which the farmers can cut a few ties or telephone poles for the market during a time when the farm work is dull, and thus derive a small revenue as well as have a means of employment.

With the owner who keeps his woodland as a game preserve, or as a playground for guests stopping at his hotel, or as protection to a watershed, and who would under no circumstances allow ordinary logging to be carried on within his holdings, a system of forest management adapted to the needs of the case is the only feasible plan. Any revenue derived is of course just that much gain, for, otherwise, no cutting would be allowed.

To the mill man or logger who is getting out his product to compete with others in the same business, any management which adds to the expense is questionable. It is evident that in most cases forest management adds to the cost of logging. It means marking the timber to be cut out or that to be left as the case may require; it means a lighter cut on the same area than would be the case under ordinary logging practice; it means greater care in felling to avoid injury to growth left for a second crop; it means care that fire shall not start; and it also means as complete a utilization of the tree as possible. In return it makes of a sawmill or paper mill plant a permanent investment, provided the owner has enough timber land to produce yearly an amount of timber equal to the annual consumption of the mill. It enables the owner to carry on his business without fear that high stumpage prices will force him out, for in raising his own timber he makes the cost considerably more constant. He has at all times on his land a valuable crop on which he can realize, instead of a cut-over area valuable only for pasture, or, in some cases, for which a small price may be secured for agricultural use. The small value placed on cut-over land is best shown from the fact that forest lands carried on the delinquent list in Michigan comprise 6,000,000 acres, and in California over 500,000 acres. In Wisconsin very large forest areas have been forfeited for nonpayment of taxes, but in 1907 the legislature authorized the purchase of such land for State forests. These forest lands are not worthless; they will in time yield timber again. They were allowed to revert to the State because their owners considered that being unprotected and subject to high tax they could not be held at a profit. Whether or not it would pay to plant these lands under present conditions is questionable, but if properly cut, so as to secure reproduction by natural means, they would probably have shown returns, even at an expense for fire protection and high taxes.

The profit to be derived from lands managed under forest principles has been carefully worked out in a number of specific cases by the Forest Service. Yet returns depend so largely upon the increase in stumpage price that figures of future returns are only conjectures.

The care of wild woods in the East will in nearly every case, by the use of very conservative figures, show a 5 per cent investment on the value of land and the cost of maintenance. If the value of stumpage at the end of the rotation exceeds the estimated value, greater returns will, of course, result. The following figures are quoted

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from Forest Service Bulletin 64, United States Department of Agriculture, Loblolly Pine in Eastern Texas:

In the following computation estimate must enter to a considerable extent, but from the tendency of lumber prices to advance it is apparently safe to assume that, after forty years, tie stumpage will be worth 8 cents and lumber $2 per thousand. The yield of the forest may easily be more than the first crop, because it will be cared for and because the area of prairie is steadily lessening, but it will be safest to count on the same yield after forty years as is obtained now.

Estimate of outlay and returns per acre in holding cut-over loblolly pine land for a second crop.

OUTLAY.

Cost of land		$0.50
Interest on same at 5 per cent	$0.025	
Taxes, at 1 per cent of value	.005	
Cost of management	.050	
Annual charge	.08	
This 8 cents paid annually for forty years, and with compound interest at 5 per cent amounts to		9.66
Total		10.16

RETURNS AT END OF FORTY YEARS.

80 ties, at 8 cents each	$6.40
2,500 board feet of lumber, at $2 per M	5.00
Land will sell for	1.00
Total	12.40
Less outlay	10.16
Net profit	2.24

This shows a 5 per cent investment with a margin of $2.24, or a net return of a little less than 6 per cent on the outlay. There is little doubt that this rate can be considerably increased in many cases, because all the figures used are conservative. If ties are cut more carefully, for instance, it will be possible to get at least 10 more from each acre, which means 80 cents, and increases the return on the investment to 6 per cent.

Other elements of this question are too problematical to be set forth in figures with safety, yet they deserve to be considered. First, the forests of eastern Texas are nowhere as dense as they might be, and it will require only a little care to increase the average stand from about 140 trees to the acre to at least twice that number. In addition, the actual forest-bearing area can be increased by reclaiming the marshes which now form so large a part of the region that the actual forest yield in these calculations is one-third of what it might be. Second, the tie supply must be kept up, and a plan which promises to do it while paying upward of 5 per cent compound interest is worthy to form part of the maintenance system of the railroads which are interested in that section.

But the best proof that forest management pays is secured from timber prices abroad, where every country but Turkey and China manage their timber lands in accordance with forest principles. In Prussia in 1904, the net return from forests was $2.50 per acre; and this is nearly ten times what it was sixty years previous.

In Saxony the net yearly revenue from forests is $5.30 per acre, the yearly expense $3 per acre. The following table is taken from Forest Service Circular 140, What Forestry Has Done. It shows what has been done by governments, states, and communities; and there is no

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reason why tracts held by private owners should not do equally as well as government holdings.

What forestry has done in other countries shows, first of all, that forestry pays, and that it pays best where the most money is expended in applying it. Both these points are very clearly brought out in the following table:

Expenditures and revenues of national forests, showing increased productiveness under larger expenditures.

Country.	Total net revenue from government forests.	Expenditure per acre.	Net revenue per acre.
Wurttemberg	$3,098,428	$2.05	$6.60
Saxony	2,299,000	3.00	5.30
Baden	829,162	3.58	4.42
Hesse	744,209	1.25	4.29
Switzerland	237,663	1.32	2.55
Prussia	17,054,144	1.58	2.50
Bavaria	5,128,348	1.99	2.22
France	4,737,250	.95	1.75
Italy	.....	.....	.33
Hungary	.....	.34	.32
Austria	5,313,000	.56	.21
Roumania	482,600	.....	.18
Spain	.....	.....	.17
Sweden	1,677,672	.02	.09
Russia	21,500,000	.01	.032
United States (1905–6)	12,000	.007	.0001
United States (1906–7)	128,659	.0093	.00086

FINANCIAL RETURNS FROM PLANTING.

The financial results to be obtained from planting depend very largely upon the locality and market. In sections of the country with ample rainfall and extensive natural forests, and where natural reproduction can be secured, it will not, for the present, pay to plant. Where timber is in great demand for all purposes and the natural forest is limited in extent, planting often pays extremely well.

For example, in Forest Service Bulletin 37, The Hardy Catalpa, the following returns are figured for some of the plantations examined:

Net return per acre.

Hannewell plantation, 18 years old	$14.78
Munger plantation, 13 years old	15.01
Farlinger forest, 21 years old	12.65
Yagge plantation, 12 years old (yearly)	7.25–21.55

These plantations are all in Kansas and the returns shown are those for each acre each year.

In Forest Service Circular 145, Forest Planting on the Northern Prairies, the following statement is made:

A single row of cottonwood trees planted 4 feet apart along the public highway has been known to produce 46.9 cords of fuel per mile in seventeen years. At $5 per cord this would have a total value of $234.50, or an average annual value of $13.80.

In the same circular the following statement is made in regard to white willow:

For this age (twenty years) cottonwood groves average 560 trees to the acre, and yield 3.56 cords of wood a year, while white willow has 1,700 trees to the acre, averaging 3.42 cords. From this comparison it will be seen that what cottonwood gains in rate of growth in the individual trees is more than com-

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pensated for in white willow by the larger number of individuals to the acre. As a lumber tree the former produces an annual net return per acre of $10.57. As a post tree, the latter produces a net return of $24.01.

And with regard to Scotch pine the following statement is made:

The maximum annual height growth attained in any one grove of this species was 3.75 feet and occurred between the age of 7 and 8 years. The trees were as high in two of the groves measured at 15 years as in another grove at 21 years. The difference in growth seems to be accounted for by the difference in character of the subsoil. In the former two it is sandy; in the latter it is loam or clay. The yield for the Scotch pine groves is estimated to be equal to an annual net return of $13.35 upon the upland as against 13 cents in boxelder, $1.71 in green ash, $0.61 in silver maple, and $2.21 in cottonwood.

Table III gives a comparison in rate of growth and yield between our available data and those for the same tree grown from the best quality of soil in European forests:

TABLE III.—*Height.*

Age.	American.	European.	Difference.
	Feet.	*Feet.*	*Feet.*
5 years	3.1	3.1	.....
10 years	13.3	7.9	5.4
15 years	24.4	16.2	8.2
20 years	31.4	25.4	6.0

TABLE III (*a*).—*Yield in cubic feet per acre.*

	Age.	Cubic feet.
	Years	
American	17	2,628
European	20	2,349
Difference	.....	334

This table, while very incomplete, tends to show that, grown in America, Scotch pine 17 years old yields 334 cubic feet more per acre than the same species at 20 years of age when grown in Europe, assuming, of course, that soil conditions were the same in both cases.

In Forest Service Circular 81, Forest Planting in Illinois, the results of a study of a large number of plantations are given:

Hardy Catalpa. A 20-year-old plantation had material on it worth $449.50 per acre.

The material on a plantation of European larch 30 years old was valued at $386.31 per acre.

A 49-year-old black walnut plantation was valued at $396.72 per acre.

A 35-year-old silver maple plantation was valued at $96.74 per acre, and other plantations showed good returns on the investment in land and the cost of starting the plantation.

In general, it can be said that forest management as an investment will pay under ordinary conditions of market and in sections where forest growth is fairly rapid. The experience of older countries proves that it pays extremely well. With wild woods in this country it is often possible, by keeping out fire and by using a little care in logging, to insure a second crop on land which would otherwise be sold at an extremely low figure or revert to the State for nonpayment of taxes. Every lumberman is willing to assume that stumpage prices will increase, and timber is bought in large quantities with this end in view. This makes it advisable to grow as well as to buy timber to hold for future supply.

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In planting the same is true. Land of little or no value can be made to yield good returns. A forest crop needs little attention and only a small outlay after the initial cost of starting. A farmer or lumberman can therefore with slight effort start a future crop which will then very largely look after itself. Forest planting has not yet secured the attention due it, not only as a necessity—if our timber supply is to be perpetuated—but as a profitable investment to the farmer or timberman.

MEASURES TO BE TAKEN BY PRIVATE OWNERS TO INSURE A TIMBER SUPPLY FOR THE FUTURE.

It is, of course, apparent that the perpetuation of our timber supply depends upon the proper handling of government, state, and private forest lands; not only that a second or future crop be secured, but that much greater ones will result. This has been done abroad and can be done in this country. Each holder must manage his lands in a rational and conservative manner. The Government must not only manage its own lands wisely, but must aid States and private owners by information and assistance; the State must aid the individual or company by wise and just fire and tax laws, so that lands will not be stripped of their timber to revert to the State for nonpayment of taxes; the private holder must so cut his land that a second crop and a better one will result.

One of the chief reasons why private owners have not more generally practiced forestry is that they have had a very vague idea of what forestry means, and of the benefits that might be expected to result from its practice; and many have still a very vague idea of what should be done to insure future crops. As has been pointed out, the method of forest management must, in every case, depend on the section of the country and even on the specific tract. In fact, it very often happens that conditions are so different over a comparatively small area that several silvicultural systems must be followed.

Yet there are certain peculiarities common to any forest region. Thus, in certain portions of the yellow-pine belt of the South (loblolly and shortleaf lands), if fires are kept out and from two to four seed-bearing trees are left on each acre, a fine stand of young trees will be secured. In the pine region of the Great Lakes, the brush, composed of poplar and wild cherry, comes in so soon after cutting that it takes several years for white pine to regain a foothold. In the southern Appalachians it often happens that the tree most desired in the reproduction is the most valuable one for lumber, and is so scattered that the logger feels he must take every one of that species and leave the less desirable kinds to seed the ground. The same thing is true in the Douglas fir forests of Washington and Oregon, and in the spruce and fir forests of Maine. In each of these cases inferior trees grow with the superior ones, and when the latter are cut the inferior are left in possession of the ground. In some cases it is necessary to destroy the inferior species, while in others careful cutting will result in a renewal of the desired kind. There is in every case a cheap and effective way of working out the problem.

A timber-land owner with property worth $50,000 should not hesitate to spend from $2,000 to $3,000 for the services of a forester in order to find out the best way in which to manage his lands. The owner of a small tract can get aid from the Federal Government and from the States either free or at a very slight cost.

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WHAT THE STATES SHOULD DO TO PERPETUATE THE FORESTS.

By FILIBERT ROTH,
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SUMMARY.

Aside from their economic functions forests have certain peculiarities as property which necessitates the passing of special laws for their protection. The chief of these peculiarities are:

1. *The time element.*—It may take one hundred years to produce a finished crop. Hence continuity of purpose and treatment are necessary.

2. The growth of each successive year on any one acre is held for years and remains as visible and taxable property. Hence there arises the common and wholly unjust practice of repeated taxation.

3. Timber tracts should be large in order to permit the most efficient management and utilization.

4. Forest land is usually cheap land. It is the tree growth which makes up the large part of the property.

5. Forests are most extensive where agriculture least succeeds, and where, therefore, there is a sparse population.

The state action which is essential for the perpetuation of our forest resources should follow along the main lines which experience has elsewhere shown to be essential. They are:

1. *Forest legislation.*—Proper forest protection is indispensable if private owners are to put timber land upon a permanently productive basis. The States must enact laws which result in effectually preventing forest fires. Much of the expense for fire protection may justly be placed upon the forest owners, but the State must safeguard forest property and provide the machinery for enforcing laws for the prevention and fighting of fires. The methods of taxing forest lands should be so modified as to encourage holding them until the crop is fit to cut or another crop is produced.

2. *State forests.*—These should cover all the rougher and poorer lands in every timber State where sufficient national forests to protect watersheds and maintain a timber supply do not exist. There is especial need that in many cases the States should buy up large areas of cut-over land within their borders and maintain them as forest reserves. New York, Pennsylvania, and Wisconsin have already adopted this principle on a considerable scale, and other States are beginning to apply it.

In discussing the subject of forestry as the care of the woods of our country, the questions constantly come up—

"Why do you ask for legislation and other state action?"

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"What is there about the business of forestry that justifies such action or makes such action desirable or necessary?"

"Is forestry of such great importance to the people at large?" or

"Is it such a peculiar business that it can not get on without state action?"

These questions are pertinent; they must be answered before suggestions for state action can be considered. Briefly it can be said that forestry asks for no bonus or special favor; it is an honest, paying business, and merely asks for the "square deal." Forestry is of vast importance to the welfare of our people; it ranks fairly second to agriculture in most of our timber and mountain States.

Some of the laws of the States are positively inimical to forestry; they make forestry as a business impossible, chiefly through unjust taxation and an utter lack of protection of rural property. These laws were mostly framed when the very word forestry was almost unknown in the country, and, therefore, without any bad intention, they left out the consideration of forestry as an important industry.

The following somewhat categorical statement will help to make this clear:

I. REASONS FOR STATE ACTION.

(*a*) THE IMPORTANCE OF FORESTRY TO THE PEOPLE.

1. *The timber supply.*—The rapid development of the iron and steel industry and the substitution of metal, stone, brick, tile, and cement for wood somewhat misled most people into the belief that the importance of timber in the household of the nation was on the decline; that we would soon be able to do without wood, and hence without forests. The fallacy of this notion is fully illustrated in another chapter of this report. We use more wood than ever, and we now realize as never before that wood is fundamentally necessary to most of our industries to-day, and that with the depletion of coal and iron (both in the reasonable future) wood, again, must form one of the principal bases of man's comfort, of his very existence. For timber may be grown always, providing we do not destroy and lay waste the earth beyond the point of recovery, but coal and metals are mined and sooner or later give out.

As stated elsewhere, in Europe, where the per capita consumption of wood is only about one-sixth what it is with us, every State that has less than 35 per cent of its land in forest is an importer of wood and timber.

The price of timber for more than one hundred years has been more uniform and has increased more regularly than that of any other raw material. This is true not only of our country but is true of all parts of the civilized world.

Wood is used so universally in every household that excessive prices, like excessive prices in bread, react at once and seriously on the welfare of all the people.

2. *The use of land.*—In the Old World, as well as with us, millions of acres of land that were once cleared of forest and tilled have been abandoned by the farmer. In the New England States alone the census of 1900 found that between 1880 and 1900 fully 40 per cent of all tilled land had been abandoned. The tendency of modern agri-

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culture is to farm intensively all good lands and lands favorably situated (about cities) and to withdraw from the poorer regions. The importance of this phase of the problem varies with different States. It means little to Iowa, where 95 per cent of all land is good agricultural land, but it means much to the Lake States, the Appalachian and New England districts, and the South, and means still more to the States of the great mountain region of the West, where many millions of acres are at too high altitude to warrant any farming, even if it were otherwise possible. All of these lands can and should be occupied by the forest, and by the use of these vast areas the forest will make a crop which will mean hundreds of millions of dollars to the people of these several States.

3. *Forest and water supply.*—The irrigating States of the West depend to a large degree on the forest to secure to them the water supply on which their agriculture is based. But even the farmer of the Central States experiences a continental climate where, every year, hot, dry spells, accompanied by severe, drying west winds, injure or destroy part of the crops. A well-distributed forest cover is the only remedy (aside from tillage of the soil) which can ameliorate these conditions. It is demonstrated by experiment that this action is of value, and there is to-day no doubt that the presence of such a forest cover frequently decides between a modest crop and an utter failure. It is here not a matter of heavy precipitation or other extraordinary action; it is merely the difference between much dry wind blowing freely over the land and the same dry wind checked locally from field to field by the scattered wood lots and the larger bodies of timber.

The influence of forest cover on the flow of streams and the general distribution of the water supply of any region is to-day universally conceded. But such an influence is of enormous value to the people of most of our States. Nor is this all; this value is on the increase; the development of water power and water transportation, going on all over the civilized world, is making this action of the forest one of first magnitude.

4. *Forest and erosion.*—The question of erosion is of such fundamental importance to every people and in every State that it well deserves special consideration. The farmer of Iowa or Mississippi may care nothing for the forest to supply him with timber, he may be indifferent as regards his crop or water supply, but he can not afford to see his land washed gradually but steadily into the sea.

The injury due to the gullying and washing of our lands is still too little appreciated. Even in the Lake States, where we have always been told about the low gradients of our river systems and the consequent safety against erosion, we lose thousands of acres of fertile land every year, as well as the choice top soil of many thousands more. This loss is enormous; it is permanent; it makes for waste land and for desert. The forest cover, properly distributed, is the only practical means of preventing it. With the experience before us of the Mediterranean countries and the sad stories of the Chinese Empire, showing two thousand years of steady deterioration of millions of acres of land, the gradual driving from the land of millions of people, and the final dissolution of once powerful nations, surely we, the enlightened people of the twentieth century, have little excuse for our indifference.

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5. *Forest and æsthetics.*—Man loves the woods. The throng of the city on a summer day is not about the piles of hewn stone and brick or brownstone fronts; it is out to the woods to enjoy the shade and beauty of the trees. This is not new; it is not due to school influences or any other artificial means; it is instinctive, rooted in the very nature of man. The traveler who finds southern Michigan to-day a "pretty country," does not mention the red barns nor the "bill-posted" back yards which the towns offer to the passing train; it is the woods, and the woods chiefly, which make this southern Michigan, like many other parts of the Union, attractive to him. The æsthetic value of the wood lots of Michigan is worth many millions of dollars, which are capable of being lost by the removal of these woods.

6. *Forest and ethics.*—Generally we preach one code of ethics for the ordinary man, another for the "extraordinary" man, either on top or at the bottom of society, and usually no code at all for the State or Commonwealth. We are getting over this Machiavellian habit, and surely, if it is proper for the ordinary man to leave to his children a decent heritage, to leave the farm as good as he found it, it is equally the concern of the State and of us individually, the people of to-day who make up this State, to leave it in as hospitable and beautiful a condition as we found it, and to avoid, at least, serious devastation. The devastation of the forest cover is one of the most conspicuous of all. The logging of the mature white pine in Michigan was good, sound business; the conversion of millions of acres of forest into blackened stump waste was a serious and unwarranted mistake; the continued burning and devastation of these same lands by a prosperous people is nothing less than a crime.

(*b*) PECULIARITIES OF THE FOREST.

In legislation or state action the peculiarities of a business necessarily require special consideration. Our attempts at railway legislation illustrate this perfectly. The forest—and with it the care of the forest, or forestry—has its peculiarities, and some of these are so very conspicuous and important that Dr. B. E. Fernow, in his excellent book, The Economies of Forestry, emphatically speaks of the forest as a property "sui generis," or peculiar enough to go into a class by itself. This same idea has served as basis of forest regulation and legislation in Europe for centuries past.

The following are probably the most important and most self-evident of these peculiarities:

1. *The time element in forestry.*—It takes many years to produce a finished crop. Timber in Germany to-day is cut at an average age of about ninety years.

2. The growth of each successive year on any one acre, i. e., the part which corresponds to the farmer's crop of the same year, is held for years, and thus remains on the land as visible and taxable property. To illustrate: Suppose a farmer plants 20 acres with corn and 20 acres with pine in 1908. In October, 1908, the corn crop is ripe, is harvested, and is sold, fed, or eaten probably before April, 1909. This crop is not taxed at all. The field is assessed as land and as land only. In October, 1908, the little forest trees, too, have

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ripened a crop, one of wood. It is a small crop, but it is a crop, and it stays on the land. By the year 1940 the cornfield has been planted 32 times and has furnished 32 crops, and the crop has never been assessed or taxed. By the year 1940 the pine trees have also made 32 crops, and all 32 crops are still on this plantation of pine trees. But now the assessor, according to our law, must assess this plantation at cash value, or as much as a box maker or wood dealer could and would give for the pine. In 1950 the pines are still there and each year's growth or crop is added and the assessment raised accordingly. If the two fields are alike in quality, the cornfield continues to be assessed at, say, $50 per acre, but the pine field is assessed $50 for land and $50 for the pine, or $100 in all. This continues up to the time when the pine is cut or harvested, say at eighty years. When that crop of pine is 75 years old the farmer is really assessed on the land and also on 75 successive crops, i. e., the growth of seventy-five successive years, on all of which he has paid taxes before and on a large part of which he has been taxed repeatedly. But this method of taxation is prescribed by law in practically all States of the Union.

3. A large part of the timber crop may actually be used (cut or sold) long before the forester declares the crop ripe, i. e., long before it is the best business to cut it.

As pointed out above, the pine could be cut for wood at twenty, for pulp at thirty, for box material at forty years, and yet it is really best for the owner and indirectly best for the people and the State that it remain and grow into saw timber, or to an age of 100 years.

4. The size of the woods has much to do with the value of a forest property, and European people have found long ago that it is bad policy to allow timber lands to be cut into too small areas or parcels. The reasons for this are many. The woods, the trees, do better in the interior of a 100-acre lot than a small 5 or 10 acre lot where wind and sun can dry out the ground. In case of fire or storm the man who owns only 10 acres of woods may lose everything, but the man who owns five tracts of 600 acres each is not likely to lose more than a small part of what he owns. The man who has only one or two logs of oak to sell in our town has to give them away or even hire a man to take them away or cut them into firewood; the man who has 200 oak logs to sell can readily find a buyer at $15 per thousand feet b. m. The experience of Europe, and of our own country as well, clearly shows that as soon as a forest is cut into small tracts it is apt to be cleared or devastated.

5. The long period between sowing and reaping necessitates in forestry that there should be continuity of purpose and action. For this reason the forests belonging to States, cities, and towns, or all large woods under direct state control, have fared well, while most private forests, especially the smaller holdings, fare poorly. This fact led, centuries ago, to more or less state interference and control of private forests, a control which even at the present day is rather on the increase than decrease among European people. The common use of the wood lot reminds us of the cases so often met with in this country. The father takes care of the wood lot, saves the large oak, ash, and other valuable trees, uses the inferior material, and in this way stores up values fully as good as bank deposits. The son, who has early learned "better" (?) living, has a poor crop, he needs

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money, and cuts the small forest. Then for a while it does not bring in any income, he tires of holding and waiting, and clears it irrespective of the future value of the farm. This case is thoroughly human, it will always be so, and only the strong hand of law can compel the son to regard the wood lot as property of a peculiar kind, from which he may never use more than the growth or real crop, and which, owing to its relation to the rest of the people, he may not clear or devastate without special permit.

6. The land used in forestry is usually cheap land, and it is the tree growth which makes up the larger part of the value. Thus the state forests of Württemberg have for years brought a net revenue of over $4.50 per acre per year. Capitalizing at 3 per cent, they are worth $150 per acre, but the land itself would be dear at $30 per acre and would not be worth $10 for agricultural purposes. Probably half of all the forest land of all central Europe could not be farmed permanently, but would become waste land in time if allowed to be cleared.

7. The capital used in forestry is large, and large holdings are desirable. The amount of labor is small. Thus $2 per acre a year is a good allowance for expenses even in Germany, while in farming, even with us, $10 per acre is but fair.

8. The net returns in forestry are rather large and are safe, and, considering the quality of the land for other purposes, these returns are often astonishing. In our country this is evidenced by the large crops or stands of timber in some of our mountainous districts and on the large expanses of sand, both North and South.

In the Old World much more exact data are available. Thus the state forests of Baden, Württemberg, and Saxony, aggregating over a million acres, have for years exceeded $4 per acre a year of net income. When it is remembered that good farm lands over a large part of the lower peninsula of Michigan are unable to produce this as cash rental, the showing surely is extraordinary.

9. The forest, unlike most agricultural crops, improves the soil and prevents its washing. The forest can use poor lands and frosty districts or situations which are otherwise valueless. This with its power to regulate stream flow and water distribution generally has forced the states of Europe into a recognition of the conception of the "protection forest," the forest which is valuable chiefly because it protects the land and prevents waste and desert and general injury to the people or state. This conception is general and fixed, and its use is extended more and more throughout Europe. Interesting is the fact that it was this conception of the protective value of the forest which decided the Congress of the United States to pass the first really important measure in favor of forestry in the New World, namely, the establishment of the national forests.

10. The forest is usually most extensive where agriculture least succeeds, and where, therefore, there is the sparsest population. But the forest can not be locked up, it can not be inspected in all its parts at a glance; on the contrary, the forest offers seclusion and a hiding place for the evildoer, and it is therefore one of the forms of property which needs specially rigid legislation and enforcement of law for its protection. This fact was recognized early in the development and settlement of central Europe. As early as the year 1200

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the local laws governing the conduct of people in the use of the forest dealt with this fact, and trespass in timber, changing of boundaries, and setting fires in the forest, etc., were all treated as special offenses. And universally it was believed necessary to provide regular guards to protect the forest, a fact entirely overlooked and neglected in our States.

II. WHAT THE STATES HAVE DONE AND ARE DOING.

ABROAD.

In central Europe, where forestry really had its beginning, the states, as represented by the ruling princes or monarchs, began as early as the year 1000 to give special consideration to the forests. The compilations of local laws, known as the "Sachsenspiegel" (1215) and the "Schwabenspiegel" (1273), recognized the importance as well as the peculiarities of forest property. As early as 1304 Emperor Albrecht ordered the reforestation of devastated areas in the Palatinate. In France the laws of 1346 organized a regular state forest service, though more or less of this organization had existed for over a century. As the states of central Europe gradually took on more definite form, the numerous local laws, orders of the nobility and the clergy, the regulations of town and village, were replaced by regular state laws, or laws having effect alike in all parts of a given state. Thus, for the little state of Württemberg the law of 1515, revised in 1641, remained state law until 1879, a period of over three and one-half centuries, and is practically in force to-day. In Bavaria the law of 1568, revised 1616, remained in force until 1852, and forms the body of the existing forest law of that state. Similarly in Baden the laws of 1614, which replaced several special laws dating back as far as 1448, remain in effect to-day. In Hesse the local laws, promulgated as early as 1338, by free cities, cloisters, and certain of the nobility, and having effect only on the territories belonging to these several powers, were replaced by the laws of 1520, 1605, and 1628.

In Saxony the laws or "Forstordnungen" of 1560, 1585, and 1598 serve the same purpose and affect the forests of the prince, the nobility, and all subjects. In France the law of 1669, as part of a general system of progressive legislation, compelled all owners of forests to obey certain regulations, believed by the great Colbert to be for the welfare and power of the state. These laws were not mere decorations or a screen for game preservation; they were plain business and proposed to avoid the devastation of the forest, to prevent scarcity of raw material for shop, mine, and marine, and to keep the useless lands covered with a useful growth. They were too severe, and were abolished by the revolution; the state forests were sold and destroyed, the private forests devastated. In 1801 a new law was put in force and a forest service organized. In 1827 the old law of 1669, considerably modified, to be sure, was reestablished, and since that time France, though a republic for thirty-seven years, has "tightened" in the matter of forest legislation.

Even Russia with its enormous forest wealth, its vast stretches of unexplored and unexploited woods, has seen fit ever since 1645

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to pass special laws with regard to forest property and its use and protection.

These laws of the different European States were a matter of development; they represented even in their first form the experience of centuries, and accordingly they have stood the test of time and prove of value to-day.

Generally these laws cover the following principal points:

1. *The ownership, purchase, sale, and management of forest property by the State itself.*—Thus every State of the German Empire owns and operates forests. The same is true of France, Austria, Hungary, Scandinavia, Russia, and other States. A notable exception is Great Britain, which owns hardly any state forests at home, but has one of the most extensive state forest systems in India and other colonies.

In Germany the States own 33 per cent of all forests, in Austria 7 per cent, in Hungary 15 per cent, in France 12 per cent, in Russia 66 per cent, in Sweden 33 per cent, and so on. These state forests are in numerous scattered parcels, and are cared for by a regular service, an organization made up of technically trained foresters assisted by a corps of protective men or guards. The expenses and income are handled by the treasury department of the State, the management is for profit, and the net income reduces by just that much the tax burden of the State. In spite of all attacks on the policy of the state forests, which were especially severe during and after the French Revolution, this policy is thoroughly established in every civilized State of Europe; it is fully appreciated and approved by all people, and the state forests are steadily increasing in almost every State. The indications are that the future of all large holdings in Europe lies in their ownership by the State itself or by corporation, city, or village under direct state control.

2. *The supervision or control of forest property by the State.*—This varies with different States; includes generally all forests belonging to cities, villages, and other public bodies, but in a number of States it is extended also to all private forests or at least to private forests under certain conditions. Usually this supervision tries to secure to the forest a businesslike care and prevent every form of misuse; and in most cases it prescribes the employment of technically trained men, the approval by state authority of the plans under which the forests are managed, and state inspection.

3. *Laws forbidding the further clearing of land or removal of the forest.*—This is really the oldest form of state action which attempts to conserve the forest cover. In some form or other laws of this kind date back as far as the year 1200, a time when the want of accessible wood material made itself felt at least locally for the first time among Teutonic peoples. These laws, which were practically general at one time, have been much modified; in some States, like Saxony and Prussia, they have been practically abolished; in others, like France, restricted to forests, taking on more or less of the character of protective forests. Generally these laws apply to all forests and provide that the owner of a forest can not clear without securing a permit from the state authorities.

4. *Laws forbidding devastation or misuse of the forest.*—These laws also are very old, were almost universal two centuries ago,

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are quite general at present, and like the preceding they apply to all forest properties. These laws call in the police function of the State only when there is evident misuse, but in this case give ample power to the authorities to interfere for the safety of the property; they have been much modified and in some States have been abolished entirely, but on the whole seem still firmly fixed with a tendency to extension through a more liberal interpretation of the idea of the protection forest. To illustrate their application: A private owner has 100 acres of woods in Baden. This forest is not really under state supervision like that of a village; he can make his own plan, hire a forester or not; he does not account to the State for the material he cuts, and is not subject to the state forest inspection. His forest is free, it is his. But he can not clear an acre without permission from state authorities, and if a state forester or rural police discovers that he is overcutting the woods seriously, to the extent of timber devastation (something like a modern Michigan logging job), the police reports the case to the authorities, an investigation is made, a hearing is had, and if the owner can not make a good case, he is warned, his cutting is stopped, he is ordered to reforest, and in extreme cases the forest may be placed for a period of years in the care of the local state forester, the State paying the owner such sums or giving him such materials as are taken from the property, and deducting the expenses which are involved in the care of the woods.

5. *The purchase and reforestation of waste lands and devastated mountain lands.*—This form of state action carried out, especially in France, the German States, Austria, and Switzerland, recognizes: The necessity of state action with regard to such lands; the necessity of forestry in the reclamation of such lands, and the inability of the private individual, the village, and even the county to do this work.

Centuries of experience; the gradual deterioration of millions of acres of land into wastes, and the accompanying evils of poverty, crime, and general lawlessness; the disturbance of stream flow, and flood, and drought—all these have taught the people and the states of Europe the necessity of this line of action. And to-day states like France, and Prussia, and the other German States, and even little Switzerland, have a regular appropriation for the purchase of such areas and for their reforestation. This work has become one of such magnitude and importance that it has resulted in the development of a definite state policy, in broad-gaged, farsighted legislation, and in the expenditure of enormous sums of money. The state usually appears as a buyer; it is represented at the auction sales of property; it buys in the land that is of little value and that is in danger of devastation. The states of Europe do exactly the opposite of what we do in most of our States, where the poor tax lands, etc., are crowded on the market at any price and to no purpose. In certain cases, as in the mountains of France and Switzerland, the state exercises its right of eminent domain and takes the lands on the principle of the greatest good to the greatest number.

6. *Adaptation of the tax laws to the nature and needs of forestry as a business.*—Though the methods of taxation of forest property are by no means uniform or alike in all States, yet they are everywhere so adjusted that forestry as a business is possible and they

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do not form an inducement to clear away the forest. Like other forest laws, they are a matter of centuries of trial and adaptation. Up to recent times forests were generally taxed on the ordinary plan of a "ground rent," or soil tax, just as the farms are taxed in our States. This form of taxation is ancient; it taxes the land only and is therefore based on what the land can produce or what it would bring if sold. In recent years this form has given way extensively to the income tax, which is based on the net income which is derived from a piece of property, and the tendency throughout Europe is toward this form of forest taxation as the only scientific and just form.

7. *The protection of the forests by special laws and by a rigid enforcement of law.*—Not only is the forest property dealt with as a property deserving the attention of Government, but all its peculiarities—the extent of the areas, the difficulty of seeing or finding the damage, the greater difficulty of catching the evildoer in the act, the serious danger of fire in the forest—are fully recognized in the protective laws of practically every state of Europe.

But what is far more important, the state action does not stop here. It is not content, as it is with us, merely to pass laws for the protection of the forest, but provides for the enforcement of the law, and it does this unstintedly and at all times and in every nook and corner of the state. There is no confusion of authority, no shifting of responsibility; there is no game warden shifting responsibility on a firewarden, and the latter claiming lack of authority; there is no $50 expense limit for a whole township, as is the case in Michigan. On the contrary, when a fire breaks out in a French or German forest, the citizens are called out, the police and foresters direct the work, and the fire is fought till extinguished. It is treated as a common enemy, and fought by the people regardless of effort, until checked. The people are not paid $2 per day and thus tempted to have more fires, as is the case with us, but they are compelled by law to help and to work. Thus the village, the town, the county, and state all hold themselves strictly responsible for the protection of forest as of other property, and the taxpayer in a German state or in France knows what he is paying his taxes for.

8. *Laws regulating the traffic in timber.*—This is tariff legislation, is quite general, and is based on the same economic principles as is other similar action. The forests of the state, forestry, and also the manufacturing interests are usually considered.

9. *Special and clearly-defined treatment of timber or the products of the forest on all public systems of transportation.*—By this means the timber market, and with it the timber business or forestry, is on a simple, well-known, and stable basis as far as transportation is concerned, much to the benefit of forester and consumer.

10. Laws relating to "protective forests," i. e., declaring that large areas of woods have such critical influence on the welfare of the surrounding country by regulation of water supply, etc., that their management becomes a matter of public concern, and warrants police or state interference and supervision.

11. Last and least come a number of various state measures which may be grouped under the general head of "encouragement" laws. Strangs to say, this line of state action is rather new in Europe, and it varies from state to state in kind, extent, and consequent

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value. In keeping with the modern belief in education, laws of this kind are becoming more numerous. In some cases the state provides, free of charge, lectures and advice to landowners, free plant material, etc.; in other cases it goes further and assists with money and men in projects of reforestation; and in several of the states encourages such reforestation by relieving the owner of paying taxes for ten to twenty years or usually for such a time as is necessary to make the trees of a plantation of some market value.

IN OUR COUNTRY.

When we remember that the per capita wood consumption in the United States is six times as great as that of other progressive people; that our national consumption has reached the enormous amount of about 40,000,000,000 feet of timber; that most of our forests are in private hands; that they are largely devastated, and that the remaining supplies are going just as fast as human ingenuity can convert them into marketable goods; and that there is no reliable, satisfactory, adequate source of supplies for this large people to draw upon in the future, the needs for state action must be apparent to everyone. And yet, compared with the magnitude and the seriousness of the problem, all of our state action appears as nothing.

State action in our country thus far has followed four somewhat distinct lines: (*a*) Protection of the forest against trespass; (*b*) protection of the forest against fire, as a special enterprise; (*c*) promotion of forestry by various means; (*d*) the establishment of state forests and forest organizations charged with the care of forests.

1. The laws against forest trespass form part of the general code of each State; they were carried from State to State and were originally borrowed from the Old World and modified to suit. In our older States these laws have been in force a long time; they are generally quite simple and direct, and usually prescribe rather severe penalties—one of the many reasons of their nonenforcement. Thus, for instance, in Michigan, according to section 11749, a case of willful or criminal trespass, though it consist merely of cutting $30 worth of timber, can be punished by five years in the penitentiary and a fine of $2,000.

These laws are not uniform; they differ in form and severity for different States, but in practically all States they are quite sufficient. But they are not enforced, and never have been in any State. The machinery for their enforcement is wanting. If the owner or his agent catches a man taking timber, he can prosecute through the proper office, bring the case into court, and if he can get the jury to convict, he can get the evildoer punished. It is a matter between owner and court and not one of police.

For a farm owner who occupies his 160 acres, this may be quite sufficient, but for the man who lives in Detroit and owns 25 different parcels of forest scattered over several counties of the Upper Peninsula, this machinery does not suffice, and in his case he must either provide his own police or leave the law unenforced. Neither town, county, nor State concerns itself about the matter, though all three share in the taxes which are paid by the forest owner.

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This is one of the causes of the peculiar attitude of the local people toward the nonresident forest owner. Though, in truth, these resident people often make their living from the tax money of the nonresident, and though the latter contributes toward every rod of road and every schoolhouse built, and other improvement, yet he is treated as if he were a wrongdoer, is taxed unmercifully, and, in addition, a trespass on his land or forest is excused and it is almost impossible in many places to get conviction. This has led in most forest States to peculiar conditions.

Thus in Michigan and other States the State itself gets no protection from the local authorities. The system of government is entirely perverted, the sheriff and the town official may even share in trespass on state lands and the State is driven to adopt a makeshift police system in the form of state trespass agents, whose business it is to guard the interests of the State.

We have here literally one part of government of the State organizing against another, or at least to do the work of the other—the part properly established by constitution for this purpose and elected under this constitution by the people. But no one is obliged to do his duty. And here lies the weakness of all forest protection by the State of Michigan as elsewhere.

That this lack of protection against trespass has not helped to conserve forests is easy to see. The owners of forest lands have been involved in endless litigation. Where the situation has been very bad they cut the timber. In many cases timber stealing was hidden by setting fire to the slash and thus wiping out the telltale evidence of cutting.

Generally speaking, the trespass laws have helped; they have protected against large and continued trespass, but their general nonenforcement by the proper authorities themselves has done serious and lasting harm to forests and forestry.

2. Usually with the first code adopted by each State came laws, derived like the laws on forest trespass, dealing with the prevention of fires in forests and on prairies. Like the laws on trespass, these earlier efforts are simple, direct, and severe. Thus in Michigan, as early as 1846, the law provided a penalty for willfully burning the woods of another, amounting to as much as five years in state prison and a fine of $500. Quite early, and in some cases as parts of the first protective act, came provisions making the fighting of forest fires a special duty of the supervisor, the justice of peace, the highway commissioner, or some other official, giving these officials power to call out the citizens and making it obligatory, under severe penalty upon the citizen, to obey such summons and to help in the fight against fire. The responsibility of the local authorities was thus clearly recognized at an early date. But there was a penalty prescribed only for the citizen and not for the officer, and so the officer found it to his political interest never to call people out.

Thus these laws (even more than the laws of trespass) remained dead letters. The difficulty of catching the evildoer, together with the ease of finding excuses in having to clear land, burn brush, cook food on camp fires, etc.; then also the matter of accident, the pipe, cigar, match, and torch, all allowed in the forest at any time and season; the general permission of anyone to travel, camp, hunt, and

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fish on other people's lands; all these made it practically impossible for the owner or his agent to bring the matter into court and secure conviction. And even if conviction were obtainable, it would have been of little value, for it is prevention of fire and not merely conviction of the firebug that is wanted. And here again State, county, and town did nothing; and with this the sense of individual as well as corporate responsibility disappeared. No one raised a hand, and the evildoer, the lone, shiftless do-nothing, who maltreats his family and his animals under the guise of being a pioneer settler, and who is ever ready to see the woods burn, could fire it to his heart's content. He could vent his spleen, or spite the thrifty neighbor; he could right the wrongs which his vicious imagination made him believe that he had suffered at the hands of the lumber company, and he could tell of the "two men with guns" whom he saw, or the "city guys" who camped there, or invent any other of the multitude of cock-and-bull stories which are circulated regularly and given emphasis by the press and the townspeople who know precious little of the situation.

It was in this way that the hundreds of fires have been started every spring for the last forty years, and it is in this way that hundreds of fires spring up in dangerous dry summers like that of 1908 and rapidly eat up the forest cover over millions of acres of land.

After a number of really great calamities, like the fires of 1871, 1881, and 1894 in the Great Lakes region, where hundreds lost their lives and thousands were made homeless, and where the damage ran well up into the millions, the situation became positively intolerable. The people clamored for action, and the legislatures reluctantly enacted a series of laws, all of which were more or less modifications of the old fire-fighting laws already in existence, and collectively perhaps best termed "firewarden" laws. Like the trespass agents and game warden laws, they are a makeshift, a duplication, and interference in what should and could be the proper administrative body of the state government. The Michigan law, copied and modified after that of New York and Minnesota and again copied by Louisiana, etc., illustrates this phase of state action. The State had a good, simple, though somewhat incomplete, forest-fire law, with a provision which made it the duty of the supervisor, justice, and road commissioner to call out the people and fight forest fires. Beyond this the State never spent a cent in protecting its second greatest natural resource and its second industry.

After enormous losses and years of agitation, the legislature in 1903 made the state land commissioner a state forest commissioner (and this in spite of the fact that he already was a member of the state forestry commission), with power to appoint a state firewarden. This man, with a salary of $500 a year, had authority over the supervisors who were thus once more legislated into the firewarden job. The earlier law was repeated in its main features, but the people were to receive pay for fighting fires, and the sum total spent in any one town should not exceed $50 in any one year, so that if $49 should once be spent the people must be sent home because no more money was available. Of this law the state land commissioner himself, in a public meeting, declared that it was not worth the paper it was printed on.

In 1907 the power of the land commissioner was transferred to the state game warden, who was made fire and game warden, the idea

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being that this office, equipped as it was by law with deputies scattered over the State, was practically a police body and thus would do better work. But when the writer asked a deputy game warden, on September 11, 1908, if he had any instructions, the reply was negative. Though the whole country was on fire and though every supervisor was by law compelled to fight, it was deemed unnecessary even to issue instructions. Again, no officer is obliged to do his duty.

The utter uselessness of these firewarden laws is amply proved by the fires of 1906 and of 1908 in Michigan; by the fires in Wisconsin, Minnesota, and New York. Aside from the small educational value of the posters, it is doubtful if these laws ever prevented a fire or put one out. The pay provision in these laws is generally conceded to be a mere temptation to build enough fire to get the state money. The forest still remains without state protection against fire.

3. The encouragement laws, or laws for the promotion of forestry in the several States, have so far been chiefly along two lines: The creation of forest commissions and, of late, state foresters, to gather and distribute information, make propaganda for forestry, and act as advisers to the legislature or government of the State; and the encouragement to plant trees or maintain forests by offering a bonus, or by exemption of the plantations from taxation. These laws have commonly been hedged in with numerous useless conditions and are usually considered unconstitutional. They have, perhaps, had educational value, but otherwise they have been of practically no use. These laws have neither planted nor preserved.

4. State action creating state forests or parks, and providing an organization for their care, has been of great and lasting value, and may well be regarded as the only one of the several state efforts which has resulted in unqualified success. Here come first New York and Pennsylvania and Wisconsin; then the smaller attempts of Minnesota, Michigan, Connecticut, Massachusetts, New Jersey, Indiana, etc., all of which have been of value. These state forests speak for themselves. They are an object lesson, and form the nucleus of what some day must be the principal center of state activity with regard to forests.

III. EXISTING OBSTACLES TO FORESTRY, WHICH THE STATE ACTION ALONE CAN REMOVE.

As more or less indicated in the preceding, there exist to-day in every State of the Union certain great obstacles to forestry as a business, and some of these threaten seriously even our present and rapidly vanishing timber supplies. These obstacles offer no extraordinary difficulties; they can be and will be overcome as soon as the legislatures of our States catch the "forestry spirit," which is now so unmistakably spreading among our people. Unfortunately, the legislatures have been reluctant in this matter; they have treated it as of the "reform sort of thing," to be looked upon suspiciously and to be put off for future and better consideration and understanding.

It is a remarkable fact in this matter of forestry, which is a purely economic matter and to the legislator means only the adjustment of law to the needs of a useful and necessary branch of agriculture, that where 90 per cent of our people are agreed that the proper measures should no longer be delayed, we still find the legislatures

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hanging back. In fact, there are few legislatures of the last five years where even 2 per cent of the legislators displayed any interest in the matter, and still fewer where even a single man could be found who was willing to put his shoulder to the wheel to accomplish what 90 per cent of the people would be glad to support.

Nor is the matter so technical. There are various ways in which the obstacles may be removed, and almost any effort can be modified and improved as time goes on. Good will and good sense are the only requisites.

The obstacles to forestry which state action alone can remove may be grouped under the following four heads: Taxation to the point of confiscation; lack of protection of forest property; personal liberty to the point of license; mistaken policy regarding state lands and the holding of lands by all public corporations, counties, towns, and cities.

1. *Unfair taxation.*—Every owner of forest land in almost every State is agreed that unjust taxation has led to premature and hasty forest clearing. Here again the conditions existing in Michigan, which apply to most of the States, will help to illustrate. In Michigan the distinction is made between the assessment and the rate of taxation, for it is the latter especially which has operated injuriously.

The assessment, according to present law, is at "full cash value" of the property. It assesses the growing crop as well as the land. How this would affect a case of reforestation has already been pointed out. It makes the tree farmer distinct from the corn farmer; it assesses only the land for the latter and the land and crop for the former, besides piling up the assessment all through the life of the trees. This method of assessment, then, is absolutely prohibitive to any effort at reforestation.

In the case of the man who owns and holds a forest already in existence the case is less unfair. He can cut and sell timber, but even here it is in danger of becoming unfair, and it usually does become so in practice, since this assessment in nowise takes into consideration what the property is making for the owner. In the case where the forest is bought merely to lumber it—that is, when only the stumpage is sold—this assessment is fair and correct in principle.

The unfair practices of excessive assessment of the forest and excessive taxation of the nonresident owner, together with the lack of satisfactory safeguards against these, need not here be considered, though these, too, have worked a great deal of harm to the forest.

The total tax rate is made up of state, county, and local (town, highway, school, etc.) tax rates. The first two are usually not high in any State. Thus for 1905 we have for Michigan: state tax, $2.46 per $1,000 of property; county tax, $2.40 per $1,000 of property; township, school, and highway, $10 per $1,000 of property; total average rate for the State, $14.86 per $1,000.

The town, highway, and school taxes (the local taxes) are levied by the local people. The few residents of one of the thinly settled towns levy these taxes, and there is no law to set a limit or maximum, and they build roads and bridges, schoolhouses, etc., whether needed and justified or not. They can make, and often have made, a large part of their living by doing the jobs which consume the local tax. It is argued: "Yes; but they tax themselves as high as

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anyone." True, but their own little properties represent but a small part of the total property of the town. It is the nonresident who commonly pays 95 per cent of all txaes levied; and it is by working (?) out this 95 per cent that they make their living and the "representative" man or local politician makes his money. What this leads to is well illustrated by the following:

In 1901 the average tax rate of one county in Michigan was over $63 per $1,000 of property; in five other counties it exceeded $40, while in 13 more it exceeded $30. And every one of these high-taxed counties was a timber county, a thinly settled district, where the nonresident, land-owning taxpayer was bled for all he would stand. In some instances the combination of assessment and rate led to the levying of a tax rate amounting to over $100 per $1,000—confiscation in ten years.

For this reason it has been one of the common questions in the timber owner's office, when deciding on where to cut next winter, "How do we fare in ——— Township as regards taxation?" If the answer is "Good," the cut is not made; if "Bad," the decision is, "Then we will locate a camp there." It is not asserted that if the tax rate had been low or reasonable and honest that the forests would not have been cut; what is asserted is this:

If the State and local people had treated the owners of timber honestly and had spent a reasonable part of the taxes in giving the protection which the owner had a right to expect under the Constitution, there would still be more than half of our pinery lands covered by forest. But this was not and is not the case. A certain forest owner in Michigan paid during the last twenty-five years over $600,000 in taxes, and it would be difficult to prove that a cent had ever been expended in the protection or real improvement of this property.

The result of this is also well illustrated by Michigan conditions. As early as 1875 over 9,000,000 acres of land, one-half of the north half of the State, was returned as delinquent or "in soak" for taxes. The owners could not afford to hold the lands, and as soon as the then marketable stuff was cut they let the land revert to the State.

2. *Lack of protection.*—This has been partly discussed above. There has never been any responsibility anywhere. The town, county, and State have acted as if the forest were not property in the ordinary sense. This was and still is especially true of protection against fire. The town officials in most States, as in Michigan, were supposed to act, but they were not compelled to, while the county officials never concerned themselves at all. Even of late years (since 1903) the case has been no better. Now and then a bit of fire fighting is done to keep the fires out of the settlement, but even then there is no head, no method, no responsibility, and in some cases it seems chiefly a matter of earning $2 per day. As stated before, the new law in Michigan has helped nothing, for the very head takes evidently no interest in the matter. Besides this utter lack of responsibility in the execution of law and the fighting and prevention of fires, there is an amount of personal liberty allowed which long ago degenerated into the worst form of license. Everyone, irrespective of character and previous record, is allowed to travel over these lands, to hunt, fish, pick berries, and camp where he

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pleases. In this way the woods are overrun by persons unknown as to name and character to any of the local authorities, and have long been the hiding places of the irresponsible and even of the criminal.

During the dangerous dry seasons some of these people are constantly setting fires, but the large areas and the difficulty of locating fire and people make it practically impossible for the few town officers to apprehend the culprits. Again, everyone is allowed to fire in order to clear land; and though the danger of this practice has been long recognized, even in our old fire laws, nothing effective has ever been done to regulate it. Under the pretext of fighting fire, or of protecting property by backfires, thousands of acres are burned over every year. In no case does the law prescribe sufficient care. Even in the driest season, when the cut-over lands especially are far more dangerous than any ordinary saw mill or similar establishment, the pernicious cigar or pipe is in common use; matches are struck and thrown into the dry, inflammable brush; campfires are built without regard to safety; shooting is done without excuse or need; and all these things go on without interference of law.

If some evildoer is actually caught in the act, the right to arrest him is not granted except to sheriff and a few officials who never concern themselves about the matter, and the man is allowed to escape. And even in cases where the guilty party is located, the juries are reluctant to convict except on the clearest proof, and the general record of the person as a notorious firebug is usually disregarded. The result is that, in spite of the fact that there are hundreds of forest fires set every year in the State, the writer knows of not one single case where the culprit has been convicted and punished.

3. *Personal liberty.*—Aside from its abuse in connection with forest protection, personal liberty has been and is held so sacred that the owner of forest properties is universally allowed to do as he pleases. He can cut and slash, burn and devastate, without interference.

It was not until within this year that at last the courts have begun to recognize the right of the Commonwealth in the matter of forest property and the treatment of it. That the misuse of any property is a wrong morally is conceded; that it is so legally is also conceded as soon as the misuse is truly serious or the property is of a peculiar character (railroads, etc.). That the unlimited, unrestricted misuse of forests by their owners was not only a mistake and poor business, but was a serious moral wrong and should have been made a legal wrong as well is just beginning to dawn upon our people.

4. *A mistaken policy toward the holding of land by the State, county, or other public body.*—Here we are concerned primarily with the matter of state lands. With the general craze to get all lands cleared and settled, and with the individualistic mercantile spirit dominating everywhere, it was but natural that the States of this Union should at all times have been eager to dispose of all their lands. That this policy resulted in much harm is now quite generally conceded, and in a few States a radical change of policy, or at least of the laws leading to such a change, has come into existence. Here again the conditions in Michigan serve well to illustrate the workings and results.

From the beginning the State sold, was eager to sell, fairly forced the sale of, all lands given to it by the Federal Government. It sold

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"cat in the bag" from the first and is selling in this same unprofitable manner to-day. The expense of a real examination was too great, and the faith in an examination by the usual political clique was too small, and so the lands went for what they would bring. For over thirty years thousands and hundreds of thousands of acres came back to the State for nonpayment of taxes (result of bad tax system). These lands cost the State millions of dollars in advertisements and clerk hire; they were again and again sold in the same fashion. To-day the State owns nearly a million acres of these lands, skinned and skinned again, several million acres come up annually "in soak" for taxes, and still the State spends money trying to get rid of them. During the past five years the State sold over 800,000 acres, received about $1.20 per acre for them, and now it is shown by special examinations that these lands had timber enough on them to pay the above sum twice over, and that thus the State gave away land and timber and young trees to the amount of millions of dollars. And what is even more pitiful, the lands thus sold are held by owners just long enough to cut off the timber—to burn them over; then they let them revert. Thus the land policy has robbed the State of millions of money, millions of acres of land, helped in further devastation of the country, and in many cases promoted a form of land speculation which is even worse than forest devastation.

Had the State kept its lands, sold them only on application and at a fair price, and separated all poor lands as forest reserves, it would have received more money, these reserves would now be producing an income instead of causing expense, and the State would be in a fair way to supply itself again with all forms of timber instead of having to import as it now does.

This general policy of "getting the lands on the tax roll" permeates all of our States. The timber counties of Michigan, of Wisconsin, and of other States could have reserved county forests and thus freed themselves from all county and state taxes by holding income-producing properties, and many of our towns could have done the same.

IV. WHAT THE STATES CAN AND SHOULD DO.

From what has been said it is clear that state action is necessary; that the lines of action be few and simple; and that such action should take very much the same form which forest legislation has taken in the older nations.

Categorically, state action should provide for: (1) A rational state land policy; (2) the establishment of state forests; (3) forest protection; (4) rational and fair forest taxation; (5) enforced right treatment of forest properties; (6) continuation of education in forestry and the encouragement of forestry among the people.

1. The State should cease to sell lands and become a purchaser of lands. It is clear that this measure must vary with the State; that it means not the same for Indiana as for Wisconsin; and that in the case of such a State as Iowa it may be dispensed with altogether.

But fundamentally it is good policy for the State to own land, and not only poor land, but good land as well, and especially for it

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to own all lands which do not promise a truly prosperous condition of settlement. This policy will be fought here, as it was fought abroad, and as it is now being fought locally in our States, by the land speculator, who revels in cheap lands—the natural goods of the land swindler. It will be fought also by the small local business man and the local politician, both of whom want, at any cost, settlement and people to live on, regardless of the ultimate harm to State and county.

As an illustration of the value of the States purchasing and owning lands and forests, the case of New York may serve. The Adirondacks lands were disposed of by the State at about 5 cents per acre; the State began buying back these lands in 1884; it has bought over a million acres, largely culled, at an average price of about $3.60 per acre, and to-day it has a holding worth at least $20 per acre, besides securing to its people one of the finest summering places and one of the beauty spots of the New World—in itself worth all that these lands have ever cost.

In purchasing lands by the States for purposes of forestry, it will be wisdom to buy good forests at good prices, as well as poor lands, and thus put the enterprise on a self-supporting basis as soon as possible.

2. Of the establishment of state forests hardly anything further need be said. If done honestly and liberally, so that the usual penny-wise, pound-foolish policy of our States does not spoil the enterprise, there is no reason why every forest State should not own and manage forests. If New Hampshire and the other New England States will only use their power of eminent domain, buy what mountain forests are needed to secure the beauty of that region, to control its waters and its industries, bond the States and secure the bonds by a mortgage on the woods, there should be no difficulty in making the forests pay the interest and, in a reasonable time, also the capital. If Michigan had kept its cut-over lands it would have had a good paying property to-day. If the Southern States will take over all their cheap cut-over lands, they will soon develop large properties which will be a blessing to future generations and prevent millions of acres of waste.

In discussing this matter much has been said in Michigan of having a certain part of every township in forests. It is a part of the scheme of leaving all forests in connection with farms, and thus making the farmer supply both wood and bread. But while it is highly desirable that the farm wood lot be preserved, that farm forestry be encouraged by every reasonable means, this plan will not suffice. There are whole counties in States like Wisconsin or Virginia that are practically all good land. In such counties the farmer will never be willing to devote more than from 3 to 5 per cent to forest, an amount entirely inadequate to supply even the farmer himself. On the other hand, there are in these same States entire counties where 85 or 90 per cent of the land is poor and not well suited to agriculture. Here the matter of forestry is foremost and becomes one of large holdings. If these holdings are in private hands it becomes either a matter of mischievous monopoly or else (what we now have) one of forest devastation and waste land, with constant conflict between the State trying to preserve and regulate and the owner trying to use up for

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his own present gain, regardless of waste. Under these conditions Europe has long since found out that it is only the State which will manage the forest well, and at the same time manage it for the good of the people.

State forests occupying all of the rougher and poorer lands should be the central figure of all state action in our country. What these forests can and should do financially has been mentioned and is discussed more fully elsewhere in this report.

3. The State should provide forest protection. In wrestling with this phase of state action the efforts have varied, but two distinct lines could always be recognized: The older measures, and those still most favored by the large majority of state legislatures, placed the burden on the town or locality where the property and the danger lie. More recent attempts, on the plea and assumption of inefficiency of the local government, have asked the State itself to undertake the protection by a properly organized state patrol. In the States where most legislation has been accomplished the discussion has resulted in a compromise, a state official, fire warden, or state forester, with one or more deputies forming the directive or administrative part, and a set of local fire wardens, either existing political officers, such as town supervisors, or else specially appointed fire wardens, forming the field service. In all cases these men are paid; the expense is usually divided between State and town. The wardens are clothed with power to call out the citizens, and the latter, and these only, are compelled to respond or be punished.

The older efforts, the placing of the burden entirely on the local people, evidently assumed that if the town gets nearly all of the taxes it should also do the bulk of the work. If the local people have to put out the fires, they will be diligent in preventing them, which is after all the main object to be accomplished.

Those arguing for state patrol maintain that the town is poor, and the burden too great for the few settlers, and that at any rate the town has proved entirely inefficient, so that if forests are to be protected the State must do it.

The use of the county authority has never entered the discussion, though in reality it may be assumed that the sheriff's office should furnish protection whenever the town authorities are unable to do so.

As stated before, in central Europe protection is furnished by the people of the locality fighting the fires, and patrol or prevention is secured through the foresters (on larger tracts), the local police, and the state police or gendarmes. But the chief feature here is that all must do their duty.

The writer himself has long favored a proper, paid state patrol, coupled with a form of special taxation which should place the financial burden on the owner of the lands to be protected. In providing state action the fact that prevention rather than fire fighting is the end desired should be kept in mind.

There are three distinct forms of state action that are to-day called for in forest protection:

(*a*) County and town should be held responsible for damages wherever it can be shown that a satisfactory, reasonable effort was not made by the town and county to protect the property against fires and incendiaries. When Allegheny County (Pittsburg) failed to make reasonable effort to protect the railway properties in 1877,

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the county was held responsible. This principle is just; without it government has no meaning. And this principle should be applied in case of forest fires. As stated above, our older laws, which simply demanded that the town fight the fires, were evidently based in part upon this principle.

If a certain county in Michigan had been held responsible for the fires of this year, the people would have prevented 75 per cent of all fires by prompt action; a number of irresponsibles would have been arrested and held until rain put an end to the danger; a number of others would have been brought into court and convicted; men would not have stood around with their guns on their shoulders merely inquiring whether the fire was coming their way instead of rendering the assistance which the law demands of them; nor would they protest against laws forbidding smoking in the woods, against the camper, hunter, and trespass during dangerous seasons, etc. This same responsibility would prevent the splitting of towns and counties. As it is, half our towns and counties were created to furnish jobs for local politicians who could no longer play boss of the larger town or county.

(*b*) Provide the machinery for the enforcement of law, the prevention and fighting of fires. Here the old original system as provided in Michigan would serve, provided it were made responsible and amplified. This could then well take on the following form: The citizens compelled to prevent and fight fires, as now, but ordinarily without pay from the State; the town officials compelled, on severe penalty, to do all in their power to prevent fires and to call out the citizens as soon as they learn of fires; the sheriff and his men to be fire wardens, compelled, on penalty, to arrest and bring to court any town official neglecting his duty as fire warden, and themselves compelled to call out men and act as fire wardens in the suppression of fires.

This system could and should be reinforced in every State by a body of state police to be distributed (say, one to each county) in all counties where 50 per cent or more of the area of the county is not occupied by farm settlers; these state policemen to act as regular police, patrol the district, enforce law in general, protect rural property, act as trespass agents for the state property, and also as game wardens if desired; to see that the county and town officials do their duty, and to have power to act as fire wardens, and in all greater emergencies to spend state funds for extra help used in such cases.

(*c*) Amplification of the forest-fire laws to regulate the following points: The right to go on other people's and state lands; the use of fire in clearing, in back firing, camp fires, etc., during certain seasons; smoking, the use of match and torch and firearm in and near forests during the dry parts of each year; the rights of men of bad record in and about forests; to make it prima facie evidence of guilt if a man is found near a forest fire where he has no business; to make it possible to prosecute officers and evildoers in a court sufficiently remote to insure impartial trial; to compel owners of woods to expend money in cleaning up their slash or guarding their forests in danger seasons; to give the right of arrest more liberally; to pay part or all of the fine to the informant. These provisions may seem harsh at present, but if enacted they would be taken as a matter of course within five years.

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(*d*) The matter of forest taxation presents several difficulties. Usually the forest lands, and especially the large holdings of the lumbermen, were acquired not with a view to hold them and to convert them into regular forest properties, but merely as so much merchantable timber or material to be cut and sold as soon as possible or as fast as the market would take it. Since these formed the majority of cases, it was rather natural that the assessment should be made on the basis of what the material was worth or what the man paid for it. Then, again, the people argued: "This property was almost given away by the Government and has cost these men far less than it is worth, and as soon as they can they remove this wealth of timber and leave us the bare land." For these reasons it seemed even quite fair that the tax-gatherer should take rather a liberal slice, with the excuse that the money would serve to build roads and make other needed improvements.

But to-day the case is different. We are now eager to preserve these woods and to make the supply last as long as it will. And the owners of many of these forests are ready to-day to hold them and to handle them as regular forest properties. In addition, there comes the matter of reforestation of vast areas of land unfit for other uses, where there is no forest and where the case is entirely as on the farm; the trees will form a planted crop, due to the efforts of the owner. To complicate matters still more, we have certain intermediate cases where the owner is undecided, and asserts that he wants to hold part of his forest, but is not ready to say what part or for what period.

Generally it is conceded that the taxes should be so modified as to encourage both the holding of forest and forest planting, and these enterprises should not be discouraged. Various remedies have been suggested:

The special tax; merely a flat rate per acre of all forest land with the proviso that these taxes be used for specific purposes. This method is simple and feasible in every way.

Harvest tax; in this case a forest goes untaxed until the timber is cut, when a certain percentage of the sale value is paid as tax. This, more seemingly than in fact, has the disadvantage of leaving the local people without taxes for a number of years. In reality there would be a lot of timber cut in such a town every year, maybe by different owners, and thus there would be a steady though somewhat irregular revenue. This method would put a premium on holding forest and thus do some good; it is perfectly simple in execution, and therefore possible.

Combination harvest and land tax; here the land is taxed right along every year at its ordinary cash value, but the timber remains untaxed until cut, when a certain percentage of the stumpage value of the cut timber is paid as tax. This method has the advantage of furnishing a regular income, at least from the land.

Simple land tax to be applicable only to real forest properties and cases of reforestation; under this system the owner declares a certain area of forests or cut-over lands, wood lots, etc., to be forest property. He signs a contract with the State which gives the State a certain lien on the property; that it can dictate that the land may not be cleared and that the forest may not be devastated. This method is the simplest of all, applies to all woods alike, would work

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no hardship to anyone, would preserve the forest, furnish a regular tax income, and still enable the holding of woods and the reforestation of denuded lands.

In this case all timber not registered would continue to be treated in the ordinary way and might be taxed on the harvest-tax plan. It might be argued that this would leave too much property untaxed, etc. The fact is that the State of Michigan, for instance, could better afford to do without the tax from all its woods, making perhaps 2 to 3 per cent of all taxes, than continue to prevent by law so necessary an industry as forestry and the preservation of the forests now in existence.

An income tax or tax based on the net income of a forest property; here again a parcel or set of parcels of land would be declared forest property, the owner entering into an agreement with the State, and the assessment would be based on the net income (usually the average for, say, five years), at a certain percentage. This is thoroughly scientific and just and might be applied to any forest property, but in our conditions would often be difficult to use, since a regular yearly income from such a property is as yet the exception.

It is evident that this matter can be adjusted in various ways, and all that is really necessary is that there be a good will and that petty politics be left out of consideration.

All but the first of the above methods deal in reality only with the assessment and still leave the most mischievous matter, the tax rate, uncured. That this should be regulated, that every State should by law set a maximum at which any property may be taxed, should be evident. The only question is: What shall be the maximum? The average rate of taxation in Michigan is about from 1.5 to 1.7 per cent. For rural property in the well-farmed counties it is nearer 1.1 per cent, and certainly it should not be allowed to go higher in the poorly settled districts and on poor lands than in the good districts. The writer believes that $12 per $1,000 should be the maximum for all rural property. That the State has a right to do this, there can be little doubt. If not, it should have the right.

(*e*) The enforcement of right treatment of the forest by the owner is a matter of long standing abroad, and yet it has hardly been suggested in this country. The matter is quite plain, a simple law forbidding clearing without state permit and forbidding forest devastation under penalty will do the work. At first this will be quite crude, it will vary from place to place according to the notion of the officials, but in time it will work out to the good of the forest and of the people. If this form of action were properly extended, all forest taxation could at once be placed on a single land tax or on a net income basis.

(*f*) The laws encouraging and promoting forestry among the people may well be adopted more generally by all States. This line of action has met with favor from the first and no doubt will continue without much agitation. Work in school, the distribution of literature, free advice and free lectures by competent, trained men, the free distribution of plant material, the establishment of sample nurseries and plantations as object lessons throughout the State, the care of street and highway trees, will help to develop an understanding and love of the tree and the forest, and thus will repay a hundredfold in a better, more beautiful home for the generations yet to come.

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PAST AND PRESENT PRICES OF FOREST PRODUCTS.

By H. S. SACKETT,
United States Forest Service.

The industrial development of the country necessarily results in marked changes in many directions. One of the favorite topics of discussion of late has been the alleged increase in the cost of living resulting from the increased cost of commodities in common use. There has been a large increase in the prices of many things, but, on the other hand, there has been a decrease in others. The result in any given case depends upon the character of the commodity. If it be one, the raw material of which is increasing in amount with the development of the country or which is in such abundant supply that exhaustion is not feared, invention resulting in decreased cost of manufacture usually makes a reduction in the selling price. This has been the case with iron and steel, which are much lower in price to-day than fifty years ago. If, on the other hand, however, it be one, the raw material of which is decreasing in amount with the development of the country and the resources of which are limited, the price must continue to advance. Such has been the case with the forest products of this nation, the prices of which have increased greatly, especially during the past two decades. This increase, however, has not been gradual. On the contrary, the prices have fluctuated from time to time, depending on the prosperity or "panicky" condition of the country. On the whole, however, the general tendency has been upward. The reasons for this are manifold, but principally the increased price may be traced to an ever-increasing demand, coupled with the realization on the part of the American people that the raw material required for these products is not inexhaustible, a condition brought about largely by the wonderful growth and prosperity of the nation. So great has been the demand that even with the increased facilities for the manufacture and transportation of the finished product and the enormous substitution of iron, brick, concrete, etc., for wood, prices have steadily advanced and our per capita consumption of lumber has increased from 215 feet in 1850 to the enormous consumption of 480 feet in 1907.

The cost of labor and of supplies of every description has during the past decade increased greatly, yet there seems to be an impression that the lumber industry should absorb all these increased items of cost and charge no more for its product.

On the other hand, the increased facilities for the manufacture of the finished product have tended somewhat to equalize this increased

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cost of labor and supplies, but have only succeeded in a very small proportion and not nearly to the extent that is generally supposed. There is an opportunity in this connection to present some figures as to the actual increase in lumber prices and in value of stumpage, which enter so largely into the cost, that ought to be convincing to the most obtuse. To be sure, stumpage is only one item of many that enters into the cost of producing lumber, but it is one which can not be ignored and which is the real keynote to the situation.

From recent reports of the Forest Service and the Bureau of the Census the following table has been compiled:

Average value of stumpage and of lumber at the mill.

	Stumpage.		Per cent increase.	Lumber.		Per cent increase.
	1900.	1907.		1900.	1907.	
White pine	$3.66	$8.09	121.0	$12.66	$19.41	53
Ash	3.03	7.58	150.0	15.84	25.01	58
Basswood	1.50	6.79	352.6	12.84	20.03	51
Hickory	(a)	6.69	.....	18.78	29.50	57
Oak	[b] 3.18	6.52	105.0	13.78	21.23	54
Spruce	2.26	[c] 5.49	142.8	11.27	17.26	53
Chestnut	2.71	4.97	83.0	13.37	17.04	27
Elm	3.30	4.94	49.6	11.47	18.45	61
Poplar	2.81	4.64	65.0	14.03	24.91	78
Cedar	1.32	4.63	250.0	10.91	19.14	75
Hemlock	2.56	[d] 4.51	76.0	9.98	15.53	56
Birch	(a)	4.40	.....	12.50	17.37	39
Cypress	1.58	4.37	176.0	13.32	22.12	66
Cottonwood	1.45	3.97	173.0	10.37	18.42	77
Beech	.....	3.56	.....	(a)	14.30	.....
Yellow pine	1.12	3.16	182.0	8.48	14.02	65
Maple	2.66	2.50	[e] 6.0	11.83	16.84	42
Red gum	1.68	2.46	46.0	9.63	14.10	46
Redwood	1.06	2.35	121.0	10.12	17.70	75
Western pine	(a)	1.66	.....	9.70	15.67	62
Douglas fir	.77	1.44	87.0	8.67	14.12	63
Tupelo	(a)	1.27	.....	(a)	14.48	.....
Average, all kinds	.....	.....	.....	11.08	16.58	49

[a] Not separately reported.
[b] White oak only.
[c] Eastern spruce only.
[d] Eastern hemlock only.
[e] Decrease.

First are given stumpage values of 1900 and 1907. Those in the latter year are the result of special inquiries made by the Forest Service, which secured more than 1,500 reports, widely scattered and obtained from authoritative sources. The lumber prices given are at the mills, and are derived from the total product for the respective years and the aggregate value.

The wood first upon the list is white pine. Its stumpage value increased 121 per cent, while the mill values increased but 53 per cent. More important, because of its larger product, is yellow pine. The increase in the stumpage value was 182 per cent and in lumber value only 65 per cent. Among the soft woods, the next most important item is Douglas fir; there the contrast is not so great, for while the stumpage value increased 87 per cent, the lumber value increased 63 per cent. Cypress shows a stumpage increase of 176 per cent and a lumber increase of only 66 per cent. Oak stumpage increased in value 105 per cent and oak lumber only 54 per cent. Cedar stumpage value increased 250 per cent and lumber but 75 per cent. It is unnecessary to go through the list, but it may be noted that among all

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soft woods the lowest increase in stumpage is only about equal to the highest increase in mill values.

The hard woods do not show such great discrepancies, but even there the contrast is marked in some cases, especially in oak and cottonwood. In some instances the lumber increase was greater than that of stumpage. The figures for maple, on first thought, might be questioned, as it is difficult to understand why there should have been any decrease in the value of stumpage as shown by the comparison. This may partly be explained, however, by the fact that maple is a wood which has a number of very strong competitors in all the uses to which it is put. This has to a large extent kept down its demand; and the building of railroads into hitherto inaccessible tracts of hard woods in the past few years has opened up a great many maple tracts and consequently thrown on the market large amounts of both lumber and stumpage, possibly even more than the demand warranted. However, the woods of largest production all show that the item of stumpage cost has increased in vastly greater ratio than the mill prices.

And why this increase in the cost of stumpage? During the past decade a most potent influence has been at work to cause this, viz, the awakening of the American people to the realization that their forest resources are not inexhaustible. The realization of an impending crisis has, during the past decade, made itself markedly felt in the lumber industry, and principally, of course, in the increase in the cost of stumpage. This is graphically shown in Table I. The increase advanced slowly for several decades but increased by leaps and bounds during the past few years. The only break noted in the continued rise in price since 1866 is from 1892 to 1896, when the decrease in price reflects the business depression which swept over the country at that time. Had not this occurred it is safe to presume that the advance would have been gradual from $7.00 in 1892 to $9.00 in 1898.

In case of wood we must not overlook that lumber prices do not really represent wood prices, for the price of a manufactured product like lumber, at places of consumption, includes the cost of manufacture, the cost of transportation, of brokerage, etc., and finally is influenced by the competition of manufacturers; changes in all of which conditions are reflected in the price. Thus it has happened that, owing to improvements in machinery, cheapening of transportation, change in methods of trade, and active competition, lumber prices have for quite long periods remained stationary, while stumpage prices, that is, wood prices pure and simple, have risen. For instance, the stumpage of white pine in Michigan rose during the twenty years from 1866 to 1887 from $1 per thousand feet, by constant steps, without a break, to between $4.50 and $6.50, while the white-pine lumber log run fluctuated during the whole period only between $11.50 at the beginning and $13 at the end, being never higher than $14 and, for five years of that period, sinking as low as $9 and $10.[a]

From this example alone we see that lumber prices do not move proportionately to wood prices and can not, by themselves, be used

[a] Report of Saginaw Board of Trade.

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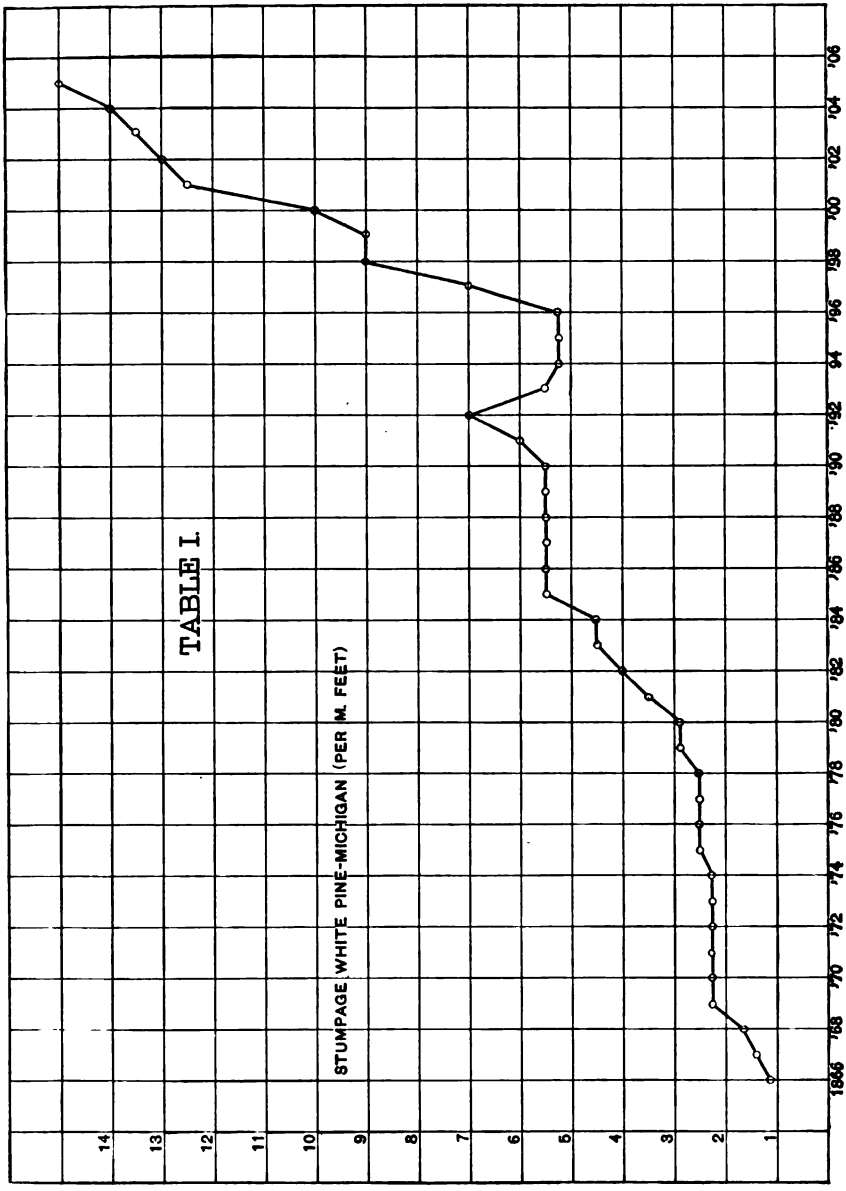
for the discussion of the latter. With regard to the variation of quality, we must keep in mind that wood is a material which serves two very different classes of purposes; namely, that in which the



substance is consumed or destroyed in its coherence, as fuel, paper pulp, excelsior, etc.; and that in which the substance is used as a whole, as lumber and construction.

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In the first class of uses quality of material, and especially the size, although a requisite, may vary within wide limits; for the second class of uses, more definite qualities, and especially certain size, which in wood is itself a quality, are requisite. Size is a function of age, and the other qualities which make satisfactory logs for lumber manufacture, namely, clean materials, free from loose knots and small taper, are also in part results of age. Hence this use of wood and this portion of the forest growth, the log timber, is the more important one, and here the time element enters prominently, which makes wood from the economic point of view a material peculiar to itself, different from any other product, owing to the long time which its production requires. As a consequence, we may find for a given region, as for instance in Massachusetts, that the price of fuel wood has not changed, or, if anything, has decreased, while that of saw timber has increased; the reason being that the local supply of material only fit for firewood has become relatively greater since the cut-over lands were robbed of the old timber and young or inferior growth has become a general feature. Similarly, we will find the prices of the best-quality lumber varying in a different manner from those for inferior grades, the latter as a rule being in oversupply and sagging in price.

Again, the importance and hence the quantity of consumption of different kinds of wood varies. The soft woods, and especially the conifers, answering the greatest variety of purposes, are the largest and most important requirement of our civilization, the hard woods being less prominent in our consumption in the proportion of three to one. Hence, although prices of the latter may be higher, their economic importance is, generally speaking, inferior to that of conifers, especially when we survey the world's sources of wood supply. We must not class the large amount of hard, beautiful, tropical woods, which are mainly for ornamental purposes, with our structural timber supply of the Temperate Zone.

The price of lumber does not parallel stumpage prices, the tendency being to more uniform and relatively lower lumber prices, owing to continental competition in the market, as well as to the cheapening of processes of manufacture, of trade, and of transportation. There are also other factors which assist in bringing about this condition, viz., the increased utilization of top logs and the decrease in diameter of cutting, as well as the use of logs formerly culled and left in the woods, thus throwing on the market a very great amount of low-grade, low-priced lumber.

Moreover, the different grades of lumber vary considerably in price and fluctuate differently, so that it is difficult to get at an average price. This is very aptly shown in Table II, where is graphically presented the rise in price of four grades of North Carolina pine from 1889 to 1908. It will be noted that the curves representing each of the four grades follow each other very closely in the general trend, though, as may be expected, the prices of low grades tend to advance slowly and high grades very rapidly, due to the growing scarcity of high-grade logs. In the resultant curve (No. 5) is shown the average price of the four grades, the grades being given the relative weights of 18 per cent for No. 1 grade, 16 per cent for No. 2, 6 per cent for No. 3, and 60 per cent for box. This proportion for all the years, however, is not a correct one, but will serve in giving a general indication of the selling price for the total product. To

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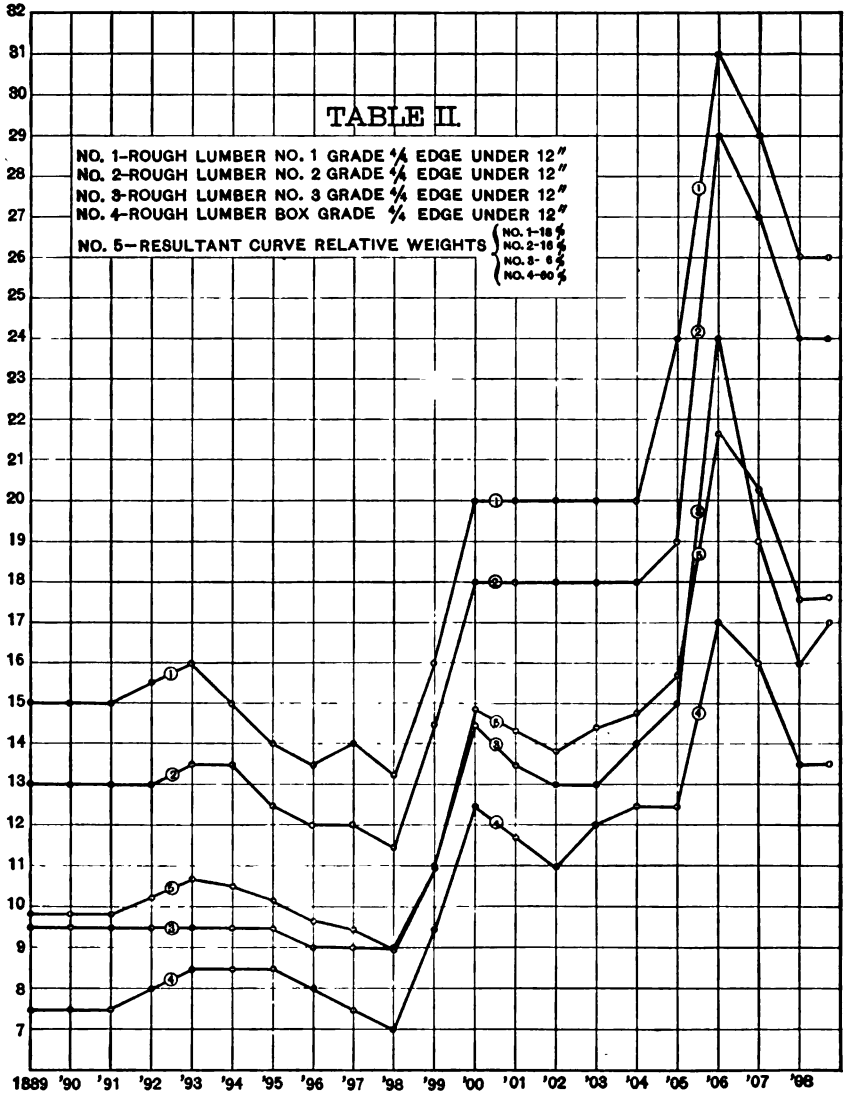
be more correct, a higher relative weight should be given the higher grades in the first decade and a correspondingly lower weight to the low grades, since at this time there was a greater percentage of high-grade logs coming out of the woods. During the past decade, however, there has been a gradual decrease in available high-grade logs, and consequently an increase in low grade. Therefore, during this



time the relative weights should be gradually decreased for the higher grades of lumber and increased for the lower. This would make the resultant curve higher during the first decade and lower in the second, thus showing that while the average price of the total product has gradually increased, it has not been so great as would appear from the resultant curve presented.

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Nevertheless, when prices of lumber of all grades rise steadily the ultimate cause may be sought in the increased cost of raw material. In Table III we have a short but significant series of prices for

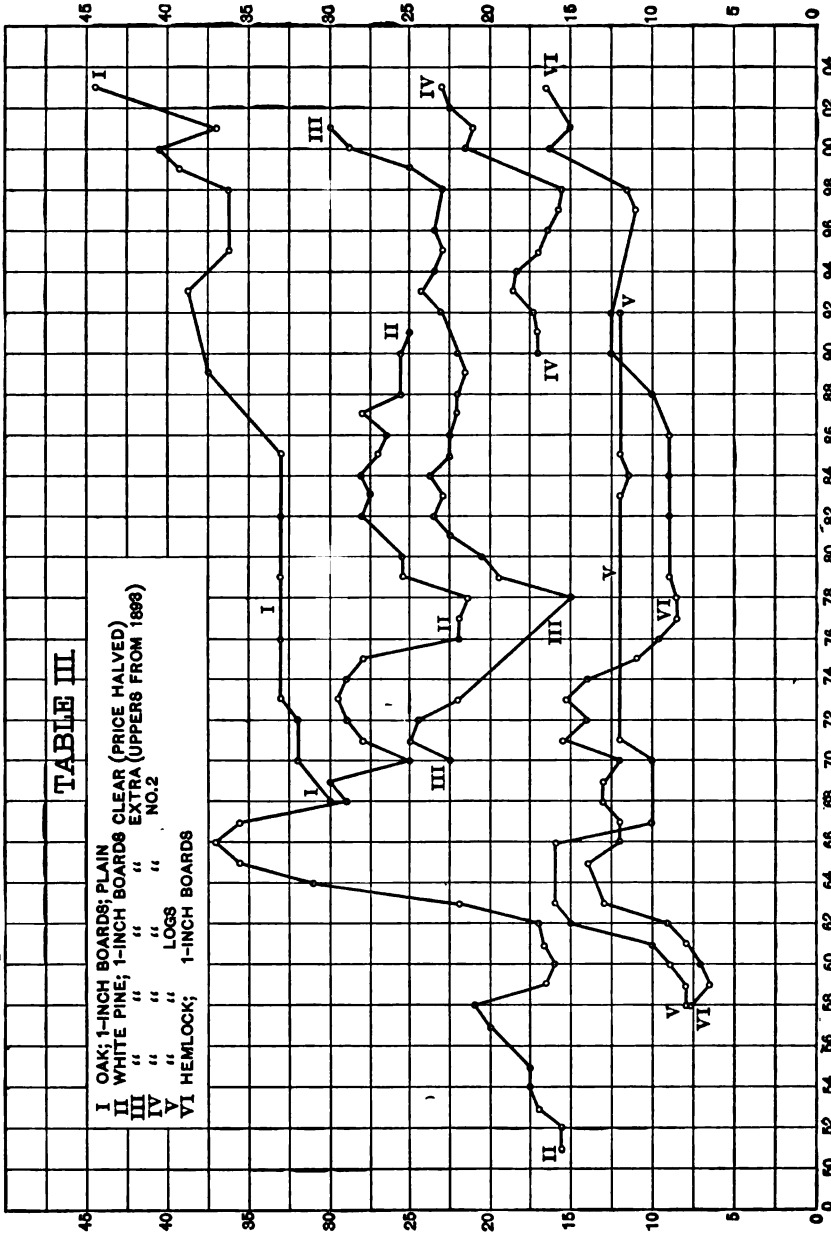
TABLE III
I OAK; 1-INCH BOARDS; PLAIN
II WHITE PINE; 1-INCH BOARDS CLEAR (PRICE HALVED)
III " " " " EXTRA (UPPERS FROM 1898)
IV " " " LOGS NO.2
V " " " 1-INCH BOARDS
VI HEMLOCK;
45 40 35 30 25 20 15 10 5 0
04 02 00 98 96 94 92 90 88 86 84 82 80 78 76 74 72 70 68 66 64 62 60 58 56 54 52 50

white pine in the log, which comes as near as possible to stumpage prices, and we find that from 1858 to 1890 the price rose from $8 to $12, with prices of $15 and $16 during the war years. Leaving these

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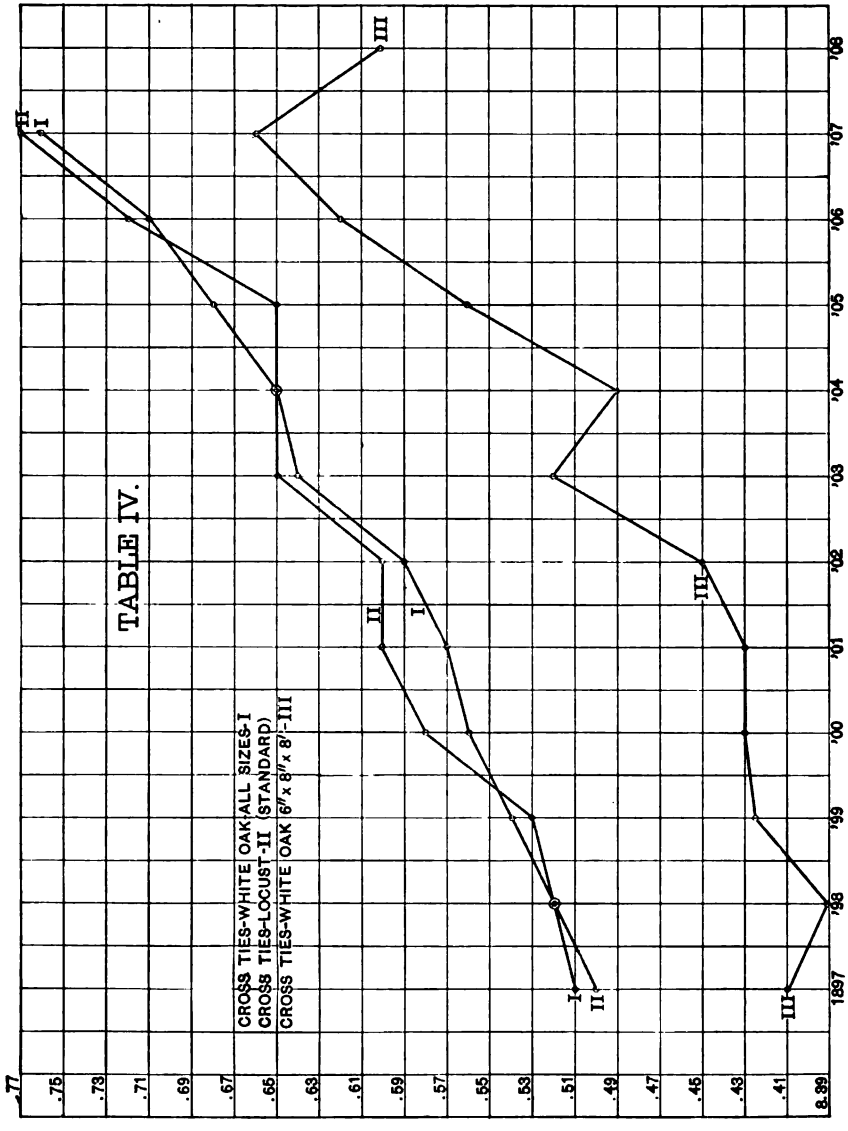
latter excessive rates out of consideration, the rise during the thirty-two years appears to be at a rate of not much more than one-half of 1 per cent. Hemlock logs rose during the same period from $6 to $8, or at the rate of about 1 per cent; white-pine lumber, 1 inch clear, on the other hand, rose from about $30 in 1840 to $50 in 1891,



or at the rate of 1 per cent, but from 1890 to 1900 the rate of rise in uppers was from $44 to $57.50, or 2½ per cent, while from 1900 to 1903 a phenomenal rise to $80, or at the rate of over 6 per cent, has taken place. At the same time the price of number two, 1-inch boards, rose from $16.80 to $24, or at the rate of 2½ per cent. The

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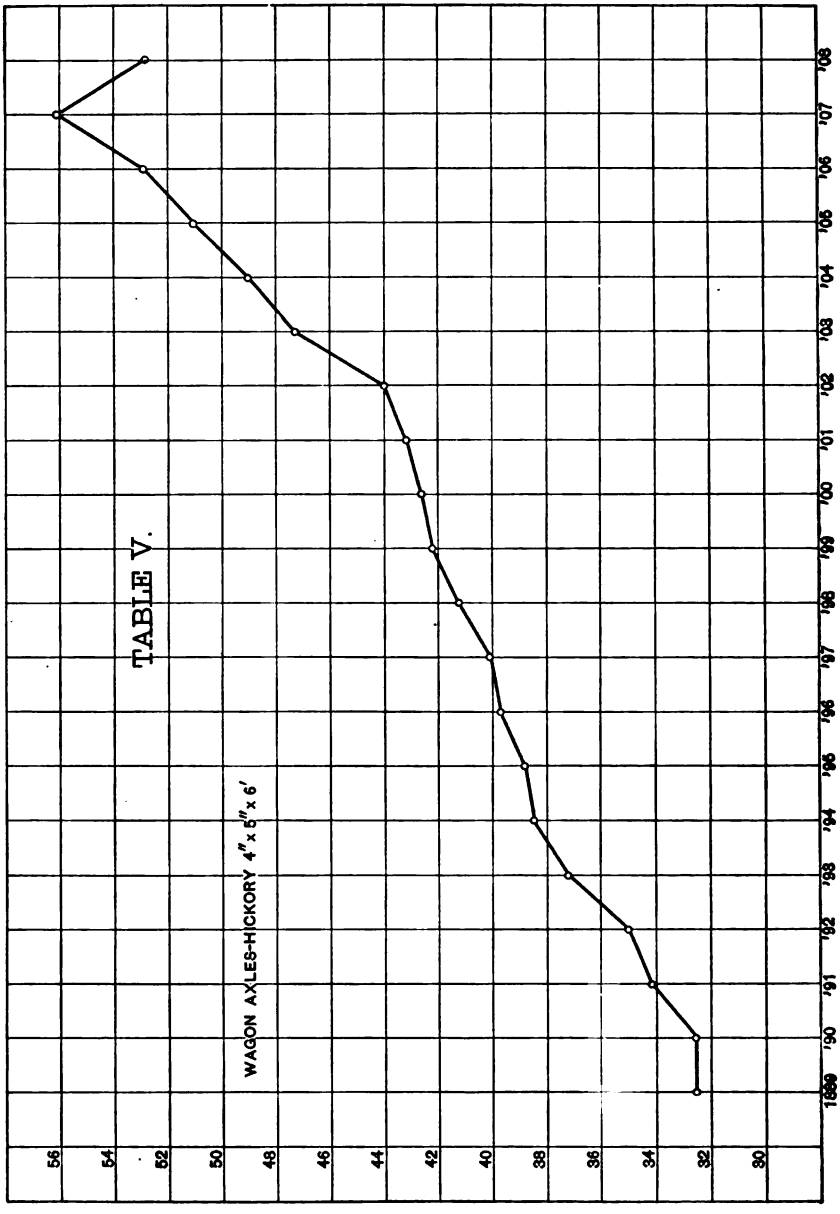
change in quality appears in the two converging curves of the earlier period, the quality uppers combining the two after 1890. It is now well known that the end of white pine as a great lumber staple is near



at hand, and hence this sudden rise, but the price of other woods also has risen, although not quite so rapidly. For hemlock inch boards the rate during the last twenty-five years has been 2¼ per cent, and

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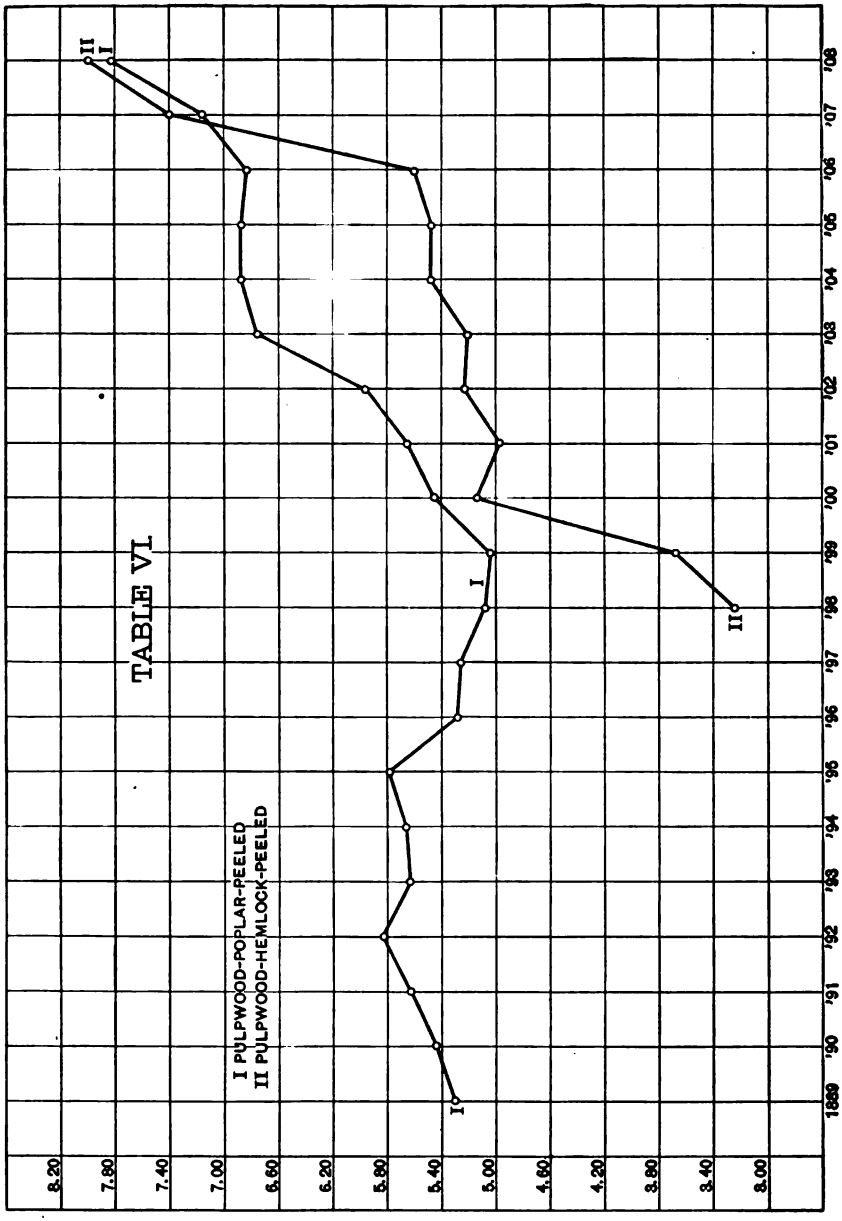
during the last ten years 3½ per cent, namely, from $12 to $16.80, and if we go back forty-five years and leave out of consideration the influence of the war years, the increase has been at the rate of 1¾ per cent per year.



Oak has risen steadily from 1868 at the rate of nearly 1¼ per cent, from $30 to $44.80, and of 1½ per cent during the last decade, it being about 50 per cent higher in price than at the beginning of the period,

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thirty-five years ago. Yellow pine, of which large supplies are still in sight, has shown little change, having in the last fourteen years hardly moved upward, although fluctuating $4 and more within that period. This evenness of price is due probably to the rapidly increasing competition among mill men in the southern section of the country, for it is well known that stumpage prices have, especially in the last ten years, grown at an almost incredible rate, stumpage of pine being held now at from $2 to $3 per thousand which ten years ago was bought for 50 cents to $1.

We may then conclude that as far as lumber prices reflect stumpage prices, these, even in the United States, in spite of the apparently large home supplies, have risen suddenly and are now rising much faster than in the period before 1890. In fact, we have reason to believe that stumpage prices are rising relatively faster than lumber prices, for the latter have a tendency to be depressed, as we have stated before, by trade competition and by new supplies becoming available and being thrown on the market, the necessities of the case forcing mill men, especially in times of industrial retrogression, to accept inadequate pay, while timber-land owners can afford to wait for improvement in market conditions.

In addition to prices of lumber and stumpage, there is also presented with this report a series of curves showing the increase in price for a number of years of other forest products.

In Table IV is shown the increase in cost of cross-ties. It will be noted that the curves for all sizes of white-oak and standard locust ties show no decrease during the past decade, while the curve for white-oak 6-inch by 8-inch by 8-foot ties reflect both the overproduction of material in 1903 and the business depression of 1907–8. The reason for this latter reflection is probably due to the fact that the 6-inch by 8-inch by 8-foot oak ties constitute the bulk of the ties used and therefore react closely with general business, while the curves for locust and all sizes of white-oak ties were held up by the cost of higher-grade material which does not readily respond to a general depression due to the decrease in their demand.

In Table V is shown the increase in the cost of hickory wagon axles. Being made from a wood which is highly prized for this purpose and which is constantly decreasing in supply and increasing in demand, no overproduction has resulted and the price has steadily increased until the general financial depression of the past year, when it fell off slightly.

In Table VI is presented the prices of hemlock and poplar pulp wood. The same general fluctuations are noted in these curves as in the preceding ones, with the exception that in the past few years the scarcity of future supplies has made itself markedly felt and the price has continued to advance most rapidly, not even reflecting the last financial depression of 1907–8.

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